An investigation into problem-solving by adults in their everyday lives

Colwell, Dhamma

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Dhamma Colwell

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Abstract

In this thesis, I report on an investigation into problem-solving by adults in their everyday lives. I observed gardeners and upholsterers at work and set up an Everyday Maths Group of women, who talked about the quantitative and spatial problems that they constructed and resolved in a wide range of situations.

The perception of problem-solving in the literature, as purely cognitive, or, alternatively, as entirely socially constructed, has lacked the perspective of the problem-solver. I developed an holistic model to demonstrate the relationship between the socio-cultural contexts in which problems were constructed and resolved, the complex logical structure of problem-solving and the participants' previous experiences, emotions and identities.

I discuss the above findings and their implications for the instructions to teachers in the Adult Numeracy Core Curriculum to use the learner's context in teaching. I propose a method of teaching that would use the stories that I have collected as a stimulus to enable learners to describe their own construction and resolution of everyday problems, in all their complexity, to teachers and other learners. Teachers could then extend the learners' knowledge and skills by facilitating the comparison of different methods and tools, including those in the formal curriculum.

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Chapter 1. The origins and development of the study

1.1 Introduction

This thesis is about the development of a theoretical model, to show how quantitative and spatial problems in everyday life are constructed and resolved within socio-cultural contexts, have complex, cyclical, logical structures and are influenced by the problem-solvers' previous experiences, emotions and identities. The model combines socio-cultural theory (Lave, 1988; Lave and Wenger, 1991; and Wenger, 1998) with constructivist theory (Confrey, 1991) and cognitive theory (Tomlinson, 1999) of learning. I argue that, if the purpose of adult numeracy education is to help students improve their problem-solving in everyday life, teachers need to recognise the problem-solving that the students already do, outside formal education. Students should also be given the opportunity to experience mathematics, by building on their everyday expertise.

In this chapter, I explain how my interest in this area developed and I discuss the focus of the study. I then outline the structure of the thesis.

1.2 How my interest in this area developed

My interest in mathematics in everyday life arose out of my experience of teaching basic maths (or numeracy, as it is now known) to adults. Adult numeracy students live in a society where adults are expected to have been 'schooled', but some have had very little schooling, for a wide variety of reasons. Some have grown up in countries where little education is available. Others have disabilities, either cognitive or physical, or both, and education has not been made accessible to them, or they have not been able to benefit from it. Some have missed some of their education for other social reasons. Other students have received eleven years of maths education, but this has been unsuccessful in teaching them much mathematics. Yet other adult numeracy students are situated somewhere between these two extremes, having received some maths education in the UK or abroad.

Students' reasons for coming to learn maths as adults are many and complex: to help their children with their homework, to try to deal with perceived failures earlier in life and raise their self-esteem, or to pass tests or examinations to gain access to further education, training or work. Most students' expectations are to learn what Nunes, Schliemann and Carraher (1993) have termed 'school mathematics': the algorithms taught in schools for calculating numbers and quantities, methods for manipulating algebraic formulae, the properties of abstract geometrical figures and the extraction of information from graphical presentations. This is probably the only kind of maths education students will have experienced in the past. But they are likely to bring with them strong feelings of anxiety and fear if they perceived themselves as failing at school (Buxton, 1981). The very act of entering a formal education situation is likely to evoke these feelings.

Many students therefore arrive at adult numeracy classes announcing that they cannot do any maths and need to start from the beginning. On talking to them it becomes obvious that many of these people are successfully managing their money and their time, using numeration, measuring or estimating quantities of materials for various purposes, understanding spatial relationships, getting themselves from place to place and doing any quantitative or spatial task that is required by their work. What they have difficulty with is 'school mathematics' (Nunes et al, 1993), but they do not make any connection between this and their competence in everyday maths (Harris, 1997b). They might view the latter as common sense (Coben and Thumpston, 1995).

As an adult numeracy teacher, I thought it was important to promote students' self-esteem by helping them to recognise the mathematical knowledge and skills they had developed through their everyday activities (Marr and Helm, 1991; Tout 1995). I felt that this would help to promote their confidence in being able to learn whatever they wanted. I therefore saw part of my role as a teacher as being to encourage students to think, discuss and write about their everyday practices at home, at work and in leisure activities, where they used numbers, quantities and concepts of space and shape.

In collaboration with other adult numeracy tutors working in Hackney, I published some of the accounts that students had written or audio-recorded, in the Take Away Times (Hackney Adult Education Institute, 1987-90), a broadsheet of student writing about maths that was distributed to adult numeracy classes in London and beyond. The purpose of publishing student writing was three-fold: to validate students' knowledge by enabling them to see themselves in print; to provide learning materials for adult numeracy classes about the maths people really use in their everyday lives and written in students' discourse, rather than tutors' or text book writers' discourse; and to use the material for the training of adult numeracy tutors.

The idea for this came from the language experience approach used in adult literacy classes (Schwab and Stone, 1985), where students are encouraged to write about their own experiences, and to develop the skills of putting ideas onto paper. Some of these accounts are then published to provide reading material, written in students' discourses, for other students to read and discuss, for example the booklet, *Every birth it comes different* (Hackney Reading Centre, 1980).

The very diverse accounts of using maths in their everyday activities, that the students produced, led me to realise that I and other teachers lacked a coherent account of what mathematics is used by adults in their everyday lives and how it is used. We knew little about how much the mathematics learnt in school is used to solve everyday problems and how much people use practices learnt outside formal education. (This was at the time of the publication of Jean Lave's Cognition in Practice (1988) and before the publication of Saxe's (1991) Culture and Cognitive Development or Nunes, Schliemann and Carraher's (1993) Street Mathematics and School Mathematics).

1.3 The focus of the study

In this study, I decided to look at people at work and see what maths they were using and how. I found the opportunity to observe an upholsterer in his professional workshop and in a community workshop where he taught upholstery to adult students and a small firm of gardeners at work in various gardens. I expected to find that professional craftspeople in these two trades would need an understanding of spatial relationships. These are areas of everyday mathematics that tend to go unrecognised (Harris, 1995).

I also convened a group of women, which I called the Everyday Maths Group, and asked the participants to tell me stories about incidents in their daily lives, which had a mathematical or numerical content. By making the discussion in the group very open, I hoped to collect stories from a very diverse range of activities, to reflect the wide range of experiences adults have in their everyday lives.

1.4 The structure of the thesis

In Chapter 2, I review literature in a number of fields, which are relevant to my study: theories of learning, emotion and cognition, everyday cognition, and adult numeracy education. I set out my research questions. In Chapter 3, I explain my methodology and describe the design of my study. In Chapter 4, I consider the methodological issues that arose during the study.

The results of the study are reported in Chapters 5 and 6. In Chapter 5, I describe the socio-cultural contexts of the problems that the participants constructed and resolved and discuss the methods and tools that the participants used in their problem-solving. I categorize the informal tools that they employed. I develop a model of problem-solving to demonstrate the complex, cyclical and logical structures of everyday problems and their solutions, within their socio-cultural contexts.

In Chapter 6, I consider the roles of emotion and identity in problem-solving. I categorize the emotions that influenced the construction and resolution of problems in the study and demonstrate their relationships to the participants' identities. I develop my problem-solving model further to demonstrate the relationship between the problem-solver, with her experiences, emotions and identity, the complex, cyclical logical problem-solving process and the socio-cultural contexts within which problems and their solutions exist.

In Chapter 7, I consider the implications of my findings for adult numeracy education, particularly in the light of the current government strategy for adult literacy and numeracy, Skills for Life (DfEE, 2000), which includes the new National Adult Numeracy Core Curriculum (Basic Skills Agency, 2001). I propose a method of teaching and learning, which would use the stories that I collected from the participants in the study to stimulate discussion amongst students and their recording of their own constructions and resolutions of problems in their everyday lives.

In Chapter 8, my final chapter, I reiterate the aims of my study from Chapter 3 and discuss how far they have been met. I outline the new knowledge that I have found and summarise the implications for adult numeracy education. Finally, I consider what further research could be done to advance the field of problem-solving in everyday life. I now turn to examining the literature that informed the study.

Chapter 2. Review of literature

2.1 Introduction

In this chapter I review literature relevant to my study. I discuss literature that informed the research questions at the beginning of the investigation and influenced the methodology and design of the study and literature that I read during the analysis and writing up of the investigation, which informed these processes.

I have organised this chapter in categories of literature. First I consider two metaphors underlying social and cognitive theories of learning. Second, I discuss literature that relates emotion and identity to cognition. Third, I consider studies of everyday cognition. Fourth, I discuss literature about maths and adult numeracy education. Finally, I present my research questions for the study. Because this was an exploratory study and I used a grounded theory analysis, my research questions were tentative at the beginning of the investigation and developed along with the analysis, writing up, and reading for the study.

2.2 Theories of learning

In this section, I discuss the theoretical basis of the thesis. I consider theories of learning as metaphors, cognitive and social theories of learning and discuss their relevance to my study.

2.2.1 Theories of learning as metaphors

Our fundamental ideas are expressed as metaphors (Sfard, 1998): we cannot help thinking in metaphors, that is how we think. They are indispensable for expressing scientific concepts, for example, 'cognitive strain', 'constructing meaning' (*Ibid*, p 5). But although they can provide great insight, they also constrain our thinking. In particular, they form our tacit beliefs and values, which are never submitted to critical reflection (*Ibid*). Sfard defines two incompatible metaphors for learning that are currently in use, the acquisition metaphor and the participation metaphor (*Ibid*).

The acquisition metaphor has been in use 'since the dawn of civilisation' (*Ibid*, p 5) to portray learning as gaining or constructing knowledge, as if knowledge were a material object. Knowledge is described as being received, acquired, internalised, appropriated, transmitted, attained, developed, accumulated or grasped (*Ibid*). It can be delivered, conveyed, applied, or transferred (*Ibid*). The acquisition metaphor treats the mind as a container, the person learning as an owner and the acquisition as permanent (*Ibid*). Knowledge is bounded and thought to be measurable, provable and displayable (*Ibid*). Identity is defined by possession of knowledge, which can confer status (*Ibid*). According to Lave (1988), psychology's and anthropology's traditional view is of society as static, learning as passive, the mind as separate from the body, and culture as opposite to logic. Problem-solving strategies are treated as fixed characteristics of individuals, knowledge as an attribute of the individual's mind, unaffected by the environment in which the person is situated (*Ibid*).

Traditional cognitive psychology focuses on the individual as learner and uses a model of transmission and assimilation of knowledge, recognising that individuals exist in a context, but leaving this unexplored (Lave, 1988). It establishes a sharp dichotomy between inside and outside, suggesting that knowledge is largely cerebral, and takes the individual as the non-problematic unit of analysis. Furthermore, learning as internalization is too easily construed as an unproblematic process of absorbing the given, as a matter of transmission and assimilation (Lave and Wenger, 1991, p 47). In the traditional view, knowledge is transportable from one place to another, and does not vary between people, except in quantity (*Ibid*).

In a capitalist materialistic society, this metaphor leads to ideas of solitary achievement and competition: to rivalry rather than collaboration (*Ibid*). Theories that see learning as the passive reception of knowledge, or as the active construction of knowledge by individuals, or as concepts transferred from society to the individual, who internalises them, are all using the acquisition metaphor (*Ibid*). This metaphor therefore encompasses individual and some social perspectives (Sfard, 1998).

The participation metaphor, Sfard (1998) finds, on the other hand, can be seen in phrases like legitimate peripheral participation (Lave and Wenger, 1991), or the description of learning as participation in an activity, apprenticeship, practice, reflection, discourse or dialogue (*Ibid*). There is no mention of knowledge or concepts: knowing is activity (Sfard, 1998). Learning is always considered in relation to the context in which it happens: it is situated, contextual, embedded in culture, and mediated by society (*Ibid*). There is no limit to learning, which is equated with becoming a member of a community (*Ibid*). This means acting according to its norms, but these are negotiable (*Ibid*). Learning is a never-ending, self-regulating process of emergence in a continuing interaction with peers, teachers and texts. Identity is defined by belonging to a community (*Ibid*). The participation metaphor is not compatible with the idea of permanence in human possessions or traits (*Ibid*). Learners are described as newcomers and reformers (*Ibid*). Participation implies being part of a larger whole (*Ibid*). There is a dialectic between the part and the whole: each depends on the other; they affect and inform each other (*Ibid*). This metaphor is expressed in democratic language like togetherness, solidarity and collaboration (*Ibid*). Learners' options are always open, which implies everlasting hope: for more democratic teaching and learning situations (*Ibid*). Knowing results from participating in the activities of communities of practice: the workplace, the family (*Ibid*), the college, the numeracy classroom. According to the participation metaphor, the actors (the learners, the teachers, the managers, the fellow workers) construct their learning between and among themselves, other people and the environment (*Ibid*). This problematises the idea that knowledge, learnt in one situation (for example, the numeracy classroom), can be carried like a set of tools and applied in a different situation (the workplace, the home, the shop), (or the other way round) (*Ibid*).

We need both metaphors to study learning, according to Sfard (1998). They both constrain our thinking in different ways and to use both is a protection against theoretical excesses and the promotion of narrow practices in teaching (*Ibid*). To allow one metaphor to hold hegemony leads to exclusivity of the concept of what is normal and what anomalous, what is above and what below average, what is healthy and what pathological (*Ibid*). To use competing metaphors leads to liberation (*Ibid*). They should be seen as different perspectives, different discourses, rather than competing opinions (*Ibid*). To do this it is necessary to be aware that we are using metaphors (*Ibid*). It would then be possible to choose the appropriate one for the task at hand (*Ibid*). Sfard (*Ibid*) thinks that it is unrealistic to expect a consistent global theory of learning.

2.2.2 Cognitive theories

Most cognitive theories, for example Piaget's work, have been developed as a result of research on children's learning: they are focused on the relationship between child development and learning. This causes some difficulty in analyzing adults' behaviour and learning: adults' abilities to develop their problem-solving skills are not increasing as a result of their bodies and brains growing and their minds developing, they are only increasing through experience.

One cognitive theory, which was developed as a result of studies of teachers in training, and is therefore concerned with adults learning, is Tomlinson's (1999) model of different categories of knowledge. The model distinguishes between different ways of knowing, explicitly or implicitly, and different kinds of things to know, knowing how to do something or knowing about something. This gives a matrix of four categories (Fig 2.1): 'deliberative action capacity', intuitive action capacity', 'explicit representational awareness', and 'implicit representational awareness' (*Ibid*, p 417). It is a useful model for considering different kinds of knowledge.

The problem with the traditional analysis of cognition, like Tomlinson's matrix (*Ibid)*, has been that the focus has been on the individual as a container of knowledge and the situations in which problems arise and are resolved have been considered to be irrelevant. Perhaps this is partly because these theories have been developed in the context of education, where 'problems' are traditionally constructed by teachers, textbook writers and examiners, not by the students. In fact the individual has been seen as being able to carry her de-contextualised knowledge from one situation to another. Her feelings and identity have also been seen as irrelevant. Socio-cultural theories, on the other hand, like Lave's (1988) and Lave and Wenger's (1991), have focussed on the situation, whilst acknowledging the individual as agent. But they have not taken into account the different experiences of individuals. Neither of these perspectives has completely explained problem-solving, which is an extremely complex process.

		KNOWLEDGE OBJECT	
		Action capacity ***(procedural/ prescriptive capacity)***	**Reality awareness** ***(descriptive/ contemplative awareness)***
KNOWLEDGE MODE	**Explicit** ***(conscious, declarative)***	(A) Deliberative action capacity	(B) Explicit representational awareness
	Implicit ***(unconscious, tacit)***	(D) Intuitive action capacity	(C) Implicit representational awareness

Fig 2.1 Tomlinson's matrix (1999, p 417)

Tomlinson's (1999) matrix is applicable to my study of people at work: the upholsterers and the gardeners were both doing practical work and therefore had knowledge of how to do it, or 'action capacity'. The theory enabled me to distinguish between when this knowledge was implicit or explicit. The upholsterers and gardeners also had theoretical knowledge about their crafts. Again, the theory enabled me to distinguish between when this knowledge was implicit or explicit. I am aware that in some cases, the fact that I was observing people, or asking questions, may have had the effect of making implicit knowledge explicit.

A limitation of Tomlinson's (1999) theory is that it focuses on cognition, but ignores emotion. Studies have found that emotion is strongly inter-related to cognition, as I discuss in Section 2.3, so that I found it necessary to modify the matrix to include emotion, as I explain in Chapter 6 (Fig. 6.2).

It is more difficult to see whether knowledge can be transferred between knowledge of how to do something and knowledge about something. In one direction this is the classic question of whether learning theory can improve practice and, in the other direction, of whether practical learning can make one knowledgeable about a subject (see Section 2.2.3.3).

I have found that Tomlinson's model (*Ibid)* has made me aware of how much everyday knowledge is intuitive. Before I looked at my data through this model, I thought that it was necessary to solve problems through logical processes, calculation or explicit estimation. But I now realise that being able to solve problems intuitively is actually more efficient most of the time: it does not require time spent on deliberately collecting together all the variables, weighing them and doing calculations (Damasio, 1996). However, when circumstances change, using intuitive knowledge seems to work less well. So perhaps using intuitive knowledge works best in familiar circumstances, but when an unusual problem occurs, it becomes necessary to work things out explicitly.

2.2.3 Socio-cultural theories of learning

According to Lerman (2000), enquiry in the field of maths education took a 'social turn', around 1988. A number of researchers began to explore the field from a socio-cultural perspective and developed socio-cultural models of learning. These see cognition as a dialectic between individuals acting and 'the setting' in which they are situated, which consist of relationships with other people, feelings, motivation, values, and tools. Cognition is seen therefore as active and dynamic: it changes over time and between situations; it is part of practice; 'a more appropriate unit of analysis is the whole person in action, acting with the settings of that activity' (Lave, 1988, p 17). Socio-cultural theories of learning counter-pose psychology's and anthropology's traditional view of society as static, learning as passive, the mind as being separate from the body, and culture as opposite to logic (Lave, 1988).

> The claim that the person is socially constituted conflicts with the conventional view in its most fundamental form, with the venerable division of mind from body. For to view the mind as easily and appropriately excised from its social milieu for purposes of study denies the fundamental priority of relatedness among person and setting and activity... The obverse side of the social character

> of the body is the partially physical character of cognitive activity. People act most commonly and most effectively in the world when employing all of their embodied senses. "Common sensibilities" ... extends the idea of "sense" to include kinaesthetic sense, embodied and mentally constructed and reconstituted experience, that is all active channels in the biographically rich, actively concerted character of experience (Lave, 1988, pp 180-1).

Several studies of apprenticeship were analysed by Lave and Wenger (1991). Yukatec Mayan midwives in Mexico, Vai and Gola tailors in Liberia, US Navy quartermasters, butchers in US supermarkets and non-drinking alcoholics in Alcoholics Anonymous were investigated by various researchers. Apprenticeship was defined in a broad way: situations where learning a particular kind of work is done within the working practice, usually without formal instruction. The Vai and Gola tailors, US Navy quartermasters and US supermarket butchers used formal apprenticeships; the other two studies were of apprentice-like situations. From these studies Lave and Wenger (*Ibid*) developed three linked concepts to describe learning as a social activity: 'communities of practice' (*Ibid*, p 42), 'legitimate peripheral participation' (*Ibid*, p 34) and 'situated learning' (*Ibid*, p 32). They described the social contexts in which learning takes place as 'communities of practice': 'A community of practice is a set of relations among persons, activity, and world.' (*Ibid*, p 98.) They depicted all human activity as happening in communities of practice, which are sometimes well-defined social groups, but are not necessarily so (*Ibid*).

> In using the term community, we do not imply some primordial culture-sharing entity. ... Nor does the term community imply necessarily co-presence, a well-defined, identifiable group, or socially visible boundaries. It does imply participation in an activity system about which participants share understandings concerning what they are doing and what that means in their lives and for their communities (Lave and Wenger, 1991, p 97-8).

A community of practice could therefore be a group of tailors working together in a workshop, midwives in a Yukatec community, who each works from home and in her clients' homes, sometimes together, the quartermasters on a US Navy ship, the butchers in a supermarket, or people who come to an A.A. meeting. Communities of practice are made up of individuals with varying degrees of experience in the community. Newcomers to the community are described as being in a state of 'legitimate peripheral participation' (*Ibid*, p 34). 'Legitimacy' indicates that they are recognised members of the community. This could be a formal recognition as when an apprentice is indentured to a master, or it could be a less formal process, such as a person going to an A.A. meeting. The term 'peripheral' refers to the position a newcomer has in a community of practice, as not knowledgeable about the practices, relationships, values or discourse of that community. It also indicates that the newcomer has less involvement and less responsibility in the community than 'old-timers', experienced members of the community.

'Situated learning' (*Ibid,* p 32) is the process of progressing from newcomer in a community of practice to old-timer. It happens by participating in the activities of the community, at first peripherally and later fully. Lave and Wenger (1991) defined all learning as situated, whether it takes place in formal educational institutions or in everyday activities and whether it is intentional or not. What are learnt are the practices, relationships, meanings, values and discourse of the community and crucially the participant's identity changes from being peripheral to being a full participant.

Identity is both a social and an individual concept: while constructed by the social context it is experienced by the individuals as an aspect of themselves. Our identities change and develop through our participation in social practices (Lave, 1988, Lave and Wenger, 1991, Wenger, 1998).

Saxe (1991) proposed another model of learning as social practice, in his study of child candy sellers in Brazil. He found that children's cognition was inextricably linked to their culture and social relationships. The activities of the children fitted the four parameter model of the inter-relationship between culture and cognition Saxe (*Ibid*) had developed in his previous work with the Oksapmin highland people of Papua New Guinea. The four parameters are 'activity structures', 'prior understandings', 'artifacts and conventions', and 'social interactions', all interacting with 'emergent goals' (*Ibid*, p 17), (Fig. 2.2).

'Activity structures' (*Ibid*, p 17) are the tasks people perform in everyday life, which are culturally determined, in their formulation and their execution. Goals emerge from everyday activities, taking new forms and varying as people use their skills and knowledge in interaction with others and alone to order and construct their environments. Within these goals there will be a number of contributory tasks, which will become apparent during the achievement of the general task (*Ibid*).

In encountering problems and tasks in everyday life, goals are formulated (*Ibid*).

> Not only do individuals shape and reshape their goals as practices take form in everyday life, but they also construct goals that vary in character as a function of the knowledge that they bring to the practices (*Ibid*, pp 16-17).

Goals, then, are emergent phenomena, shifting and taking new forms as individuals use their knowledge and skills alone and in interaction with others to organise their immediate contexts (*Ibid*, p 17).

In 'social interactions' (*Ibid*, p 17), other people may both influence the goals a person sets herself and be involved in the achievement of the goals. 'Conventions' (*Ibid*, p 17) are the accepted ways of doing things in the culture, for example writing, calculation algorithms and the idea that money is a fair exchange for goods and services; and 'artifacts' (*Ibid*, p 17) are the tools that are used in the culture, both concrete and mental.

Saxe identified 'prior understandings' (*Ibid*, p 17) as one of the elements involved in the emergence of goals and the attempts to achieve them. This is similar to Lave and Wenger's (1991) idea that individuals in a community of practice are also members of

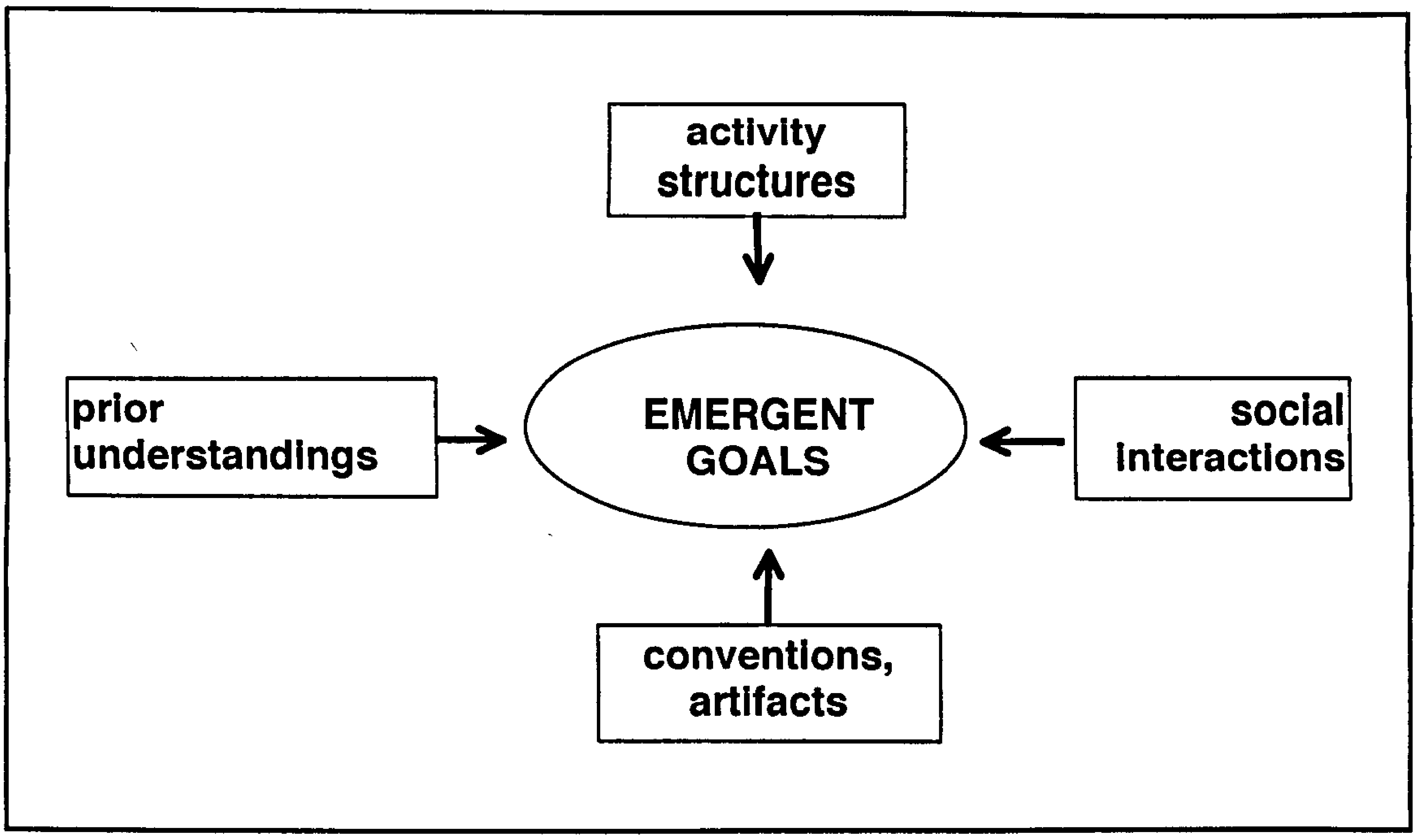


Fig. 2.2. Saxe's four-parameter model (1991, p 17)

other communities, either previously or concurrently. They have other experiences and other identities, which they bring with them to new situations and can use in the solution of problems, which might then develop as part of that community's practice (*Ibid*). Communities of practice are not static entities: they change with the individuals who join them just as those individuals are also changed (*Ibid*).

Saxe's (1991) socio-cultural model is a useful one for examining activities both outside and within the classroom. He proposes that,

> culture and cognition are constitutive of one another.... Social conventions, artifacts, and social interactions are cognitive constructions and cannot be understood adequately without reference to cognizing individuals. At the same time, individuals' cognizing activities are interwoven with conventions, artifacts, and other people in accomplishing problems of everyday life. (Saxe, 1991, p 184).

The cognition of the children, which was developing during their candy-selling work, was inextricably linked to their culture and social relationships (*Ibid*).

2.2.3.1 Access to communities of practice

How much access newcomers have to tools, activities and members of the community, controls how much they can participate and therefore how much they can learn (Lave and Wenger, 1991). The learning process starts with a general impression of what the community does (*Ibid*).

> This uneven sketch of the enterprise might include who is involved; what they do; what everyday life is like; how masters talk, walk, work and generally conduct their lives; how people who are not part of the community of practice interact with it; what other learners are doing; and what learners need to learn to become full practitioners (Lave and Wenger, 1991, p 95).

Gradually the learner builds a more comprehensive picture through participating in the activities of the community:

> It includes an increasing understanding of how, when, about what old-timers collaborate, collude and collide, and what they enjoy, dislike, respect, and admire. In particular, it offers exemplars (which are grounds and motivation for learning activity), including masters, finished products, and more advanced apprentices in the process of becoming full practitioners (Lave and Wenger, 1991, p 95).

In situations of sequestration, where newcomers are not given full access to the knowledge and activities of the community, they are not able to learn to be full members (*Ibid*). An example of this is where the butchers' apprentices were put to work on a meat-wrapping machine out of sight of journeymen and master butchers who were cutting the meat (*Ibid*). The apprentices felt unable to enter the room where the meat was being cut and were therefore not able to learn how to do this (*Ibid*). Lave and Wenger (*Ibid*) liken this to students on academic courses who do not have access to the professional practice of a subject, but only to the professional practice of a teacher.

2.2.3.2 Tools

Tools carry the heritage of a community of practice in both their development and how they are used (*Ibid*). 'Thus, understanding the technology of practice is more than learning to use tools; it is a way to connect with the history of the practice and to participate more directly in its cultural life.' (Lave and Wenger, 1991, p 101.) For example, the US Navy quartermasters were learning to use an alidade, an instrument for taking bearings, which has been developed over hundreds of years to aid navigation (*Ibid*). They were not only learning a skill, but also learning something of the history of navigation; 'using artifacts and understanding their significance interact to become one learning process.' (*Ibid*, pp 102-103.)

Tools, as well as other aspects of a community of practice, can be 'invisible' or 'visible' (or 'transparent' or 'opaque') (*Ibid*). 'Invisibility in the form of unproblematic interpretation and integration into activity, and visibility in the form of extended access to information.' (*Ibid*, p 103.) The design of a tool can contribute to its visibility: if an observer can see what the user is doing with a tool, then she can begin to learn to use that tool (*Ibid*). However, access to the use of tools by newcomers is often controlled by experienced practitioners for particular purposes:

> ... the transparency of any technology always exists with respect to some purpose and is intricately tied to the cultural practice and social organization within which the technology is meant to function: It cannot be viewed as a feature of an artifact itself but as a process which involves specific forms of participation, in which the technology fulfils a mediating function. ... In focusing on the epistemological role of artifacts in the context of the social organization of knowledge, this notion of transparency constitutes, as it were, the cultural organization of access (*Ibid*, p 102).

2.2.3.3. The question of transferability of learning between situations

The most controversial part of socio-cultural theory is its questioning of whether learning is transferable from one situation to another and, in particular, whether mathematics learnt in school is usable outside educational institutions. 'The ideology of schooling claims legitimate hegemony of school arithmetic over the math practices of alumni in the settings of their after-school lives.' (Lave, 1988, p 100.) The work of educational institutions is based on the assumption that learning can be transferred from the classroom to the work situation or other areas of everyday life.

> Conventional academic and folk theory assumes that arithmetic is learnt in school in the normative fashion in which it is taught, and is then literally carried away from school to be applied at will in any situation that calls for calculation (*Ibid*, pp 4-5).

Lave claims that studies aiming to prove transfer from school to everyday life are flawed: their results are ambiguous and volatile (*Ibid*). She and Nunes, Schliemann, and Carraher (1993) found that people use different strategies for solving problems in their everyday lives to those taught in schools. She challenges the very foundations on which maths education is based, the rational for providing hours of compulsory maths education every week to all schoolchildren: that learning maths in school will provide them with a portable tool-kit which they can produce and use in any situation (*Ibid*, 1988). The predominance in traditional psychology of the idea of transfer of learning is rooted in positivist epistemology: culture is seen as knowledge stored in the individual's brain (Lave, 1988). Educational institutions have a vested interest in maintaining this idea (*Ibid*). Lave's alternative view is that,

> ... a more appropriate unit of analysis is the whole person in action, acting with the settings of that activity. This shifts the boundaries of activity well outside the skull and beyond the hypothetical economic actor, to persons engaged with the world for a variety of "reasons;" it also requires a different version of the everyday world. (Lave, 1988, pp 17-18.)

The idea that there is no transfer of learning from one situation to another does not make sense as a global statement. For example, children who learn to talk at home would have to re-learn this skill at school if they were not able to use what they had learnt in one situation, in another.

Anderson, Reder and Simon (1996) challenged Lave's claim that knowledge gained in the classroom cannot be used outside. They discussed the relative costs, in terms of time and resources, of different combinations of abstract and specific instruction for different requirements, depending on whether the trainees are intending to do one job or a variety of work. They advocate 'a combination of abstract instruction and concrete illustrations of the lessons of this instruction' (*Ibid,* p 8). They offer examples of when abstract learning is purported to assist in solving practical tasks. A famous experiment by Scholckow and Judd (Judd, 1908), which was subsequently replicated by Hendrickson and Schroeder (1941), investigated whether teaching participants about refraction of light would enable them to shoot arrows (or airgun pellets in the replicated experiment) under water more effectively.

The boys in the experiment were asked to practice shooting at a target 6 inches under water, and when they had become competent at this, were asked to shoot at a target 2 inches under the water. In the replicated experiment, an explanation of the refraction of light was given to two experimental groups, and one experimental group were also told how the theory applied to the task at hand. The members of the control group were given no explanation. Anderson et al (1996) claim that 'the group with abstract instruction did much better' at the second task (p 8). However, what Hendrickson et al (1941) actually say is that although the theoretical knowledge did help the participants to shoot more accurately, the members of the third group, who were given a further explanation of how the theory applied to the particular task, performed better than the group who were only told the theory.

> The definiteness or completeness of the theoretical information had a direct effect both on initial learning and transfer. Even in as simple a problem as that presented to the subjects of this study, it is clearly important for a teacher to consider carefully the adaptation of any theoretical statement to the specific needs of the learner (*Ibid,* p 213).

By this, I think they mean the needs of the learner for the particular task, because the extra explanation was not given differently to different boys. They go on to say that, 'the importance of individual discovery of the solution - of the emergence of a sudden insight, in Gestalt terms - is apparent. In each group and for each problem the typical boy worked unsuccessfully for a time, then quite abruptly reached a solution' (*Ibid*, p 213). So it was a combination of the abstract instruction and the opportunity to practice, which enabled the boys to achieve success. 'The appearance of this moment of discovery undoubtedly was hastened in many cases by the theoretical explanations provided for the experimental groups' (*Ibid*, p 213).

The difference between the groups was not as clear cut as Anderson et al (1996) suggest.

> On the other hand, the large individual differences within each group and the consequent overlapping of the various groups in speed of learning suggest that success in the type of problem presented is probably conditioned by other factors in addition to the knowledge of a theoretical principle as formulated by a teacher (Hendrickson et al, 1941, p 213).

Hendrickson et al (*Ibid*) concluded that characteristics of the individuals were important factors in how quickly they learnt to shoot accurately. 'Such additional factors may include fluidity and variability of behavior when faced by a problem, a habit of verifying one's own judgements, and the ability to formulate a general principle for oneself' (*Ibid*, p 213).

Such experiments, however many of them there are, are hardly justification for the whole of the educational curriculum to be based on the principle of teaching abstract concepts first and then asking students to apply them to contextual examples. For one thing, the motivation is entirely different: how many boys would prefer to spend their time doing school maths problems rather than shooting at targets. Only a small proportion, I think.

Anderson et al did not consider another option: the solving of a practical problem, followed by discussion to identify what is generalisable about the solution and what kinds of solution strategies were the most successful. In the example of the construction of a 'magic square' in Brown et al (1989, p 38), the students constructed the abstraction, rather than being given it. The fact that this was done after the practical problem was addressed, enabled the practical problem to exemplify the general principle.

Greeno (1997) takes Anderson et al (1996) to task for confusing the dichotomy of 'abstract' and 'concrete' with that of 'general' and 'specific' (Greeno, 1997, p 7). I also find these distinctions confusing. For example, is a magic square abstract or concrete? Although a particular piece of paper with a particular magic square on it has a concrete form, the fact that it is considered the same as another magic square drawn on a blackboard means that there is also an abstract form of it. And the magicness of the square, the combination of relationships between the numbers, is abstract. There are also generalisable properties of magic squares, for example that in a 3 x 3 square, the middle number in value must be placed in the middle of the square. These generalisations are also abstract.

The boys in Hendrickson and Schroeder's (1941) study were performing two specific and concrete tasks: shooting at targets 6 inches under water and 2 inches under. The instruction two of the groups were given seems to be a combination of abstract theory, about the speed of light and the bending of light, which is general to any situation involving light, and practical application, 'we suppose that the stone lies in a straight line from our eye, and we make the mistake of thinking it at point B' (*Ibid,* p 213), which is general to any situation where someone is looking at an object under water. The instruction given only to the third group was more specific to the task, 'It is easy to see from the diagram that the deeper the lake is, the farther the real rock A will be from the image rock B' (*Ibid,* p 209). But in spite of talking about a 'real rock' (*Ibid,* p 209), this is still an abstract formulation: the 'real rock' only exists in the diagram. Similarly in school maths problems which are contextualised, like Brown et al's (1989) example of Mr. Smith filling a bath with a leaky bucket, students know that the situation is abstract: Mr. Smith does not exist, he is an abstract person with an abstract hole in his abstract bucket which leaks at a specific (but abstract) rate.

Greeno (1997) asserts that 'it is perfectly consistent with the situated perspective that abstract representations can facilitate learning when students share the interpretive conventions that are intended in their use' (*Ibid,* p 13). In the case of the experiment of shooting at targets under water, 'the meaningful abstract representation of refraction oriented students to properties of the situation in a way that resulted in their learning a more generalizable way of interacting with the material systems in the situation' (*Ibid,* p 13). As Greeno says,

> There is much that we do not understand about the ways abstract representations function in activity. Part of the power of abstraction is in people's ability to use representations to orient their attention to properties and relations in situations that are important in activity... Another crucial property of abstract representations is that the representational materials themselves - the symbolic or iconic expressions that are written or drawn - can be manipulated as objects, supporting explorations of possibilities and evaluations of relations such as implication or consistency between different statements. There has been a considerable amount of research into the processes of reasoning in some of the formal systems of logic and mathematics, but the question of how these systems

can support learning in conceptual domains and reasoning in domains of application has been addressed much less' (1997, p 13).

Lave and Wenger's (1991) view of the transferability of knowledge is that individuals join communities of practice with their own unique experiences and qualities. Just as the community acts on the individual and transforms her identity, the individual also affects the community, which is not a static entity but a continually developing and changing one (*Ibid*). An individual can enter a community of practice with experience gained in another community and make a link between the two communities (*Ibid*). If the knowledge of the old community is meaningful in the new community, it could become part of the knowledge of that community (*Ibid*). Meaning always has to be negotiated and renegotiated (*Ibid*). Lave and Wenger's theory (*Ibid*) provides a challenge to concepts in numeracy like basic skills or key skills, that are supposed to be learnt separately and then applied to any vocational area or everyday practice. They see this as unrealistic.

A degree of transfer of mathematical knowledge from one situation to another was found by Nunes, Carraher and Schliemann (1993) in their study of the maths people use at work in Brazil. The researchers studied market traders calculating prices, fishermen calculating the price of caught fish from the retail price of prepared fish, building site foremen using scale plans to calculate sizes for construction, carpenters and their apprentices calculating the timber required for building wooden beds, and farmers calculating the numbers of plants needed for pieces of land of particular sizes. They found that their participants could transfer knowledge from one situation to another, as long as the situations were meaningful to them.

Their subjects, who were uneducated or minimally educated, were able successfully to calculate ratios that were not met in their working situations and were also able to solve problems that inverted their customary practice. For example, building site foremen were able to use building plans with unfamiliar scales to deduce the measurements of materials for the construction of buildings. Fishermen were able to transfer their skill of calculating the ratio of how much prepared fish could be made from the fish they caught, to a hypothetical situation with fish of a different yield. The fishermen were also able to calculate ratios in an agricultural context, about the yield of ground cassava from fresh cassava.

However, they found that, in a school situation, the participants were not able to do calculations that were similar to calculations that they could do in their everyday lives. Nor did they use any experience they had of school maths in their everyday lives. This reinforces Lave's (1988) and Lave and Wenger's (1991) deduction from their work, that school maths is not used in everyday life: problem-solving in everyday life is learnt by participating in practices in everyday life.

Calculation or estimation and spatial relationships are elements in the solution of larger problems or the achievement of goals that are socio-cultural in nature. These are concerned with people's social relationships, their feelings and sense of self-identity, with social conventions. They may also be concerned with satisfying basic physical needs like food, clothing and housing, or earning money to pay for these things; but the ways in which people meet these needs are determined by the societies in which they live. The mathematics provides useful ways of contributing to the solution of these problems, but is not an end in itself. It is therefore appropriate to look at the maths in the whole socio-cultural contexts in which it is used, rather than attempting to isolate or abstract it.

2.2.3.4 The relationship between the individual and the socio-cultural context

Lave and Wenger's (1991) and Saxe's (1991) theories foreground the socio-cultural contexts in which problems present themselves and are solved. They tend to let these overshadow the person and their individual contribution to the formulation and resolution of problems. Most other theories of learning focus on the individual: while they may acknowledge the learner's context as important, it is treated as background information.

It is necessary to look at both aspects, as Sfard (1998) suggests (see Section 2.2.1): the socio-cultural environment in which the individual and the problems are situated and the individual as agent in the formulation and resolution of problems. It is rather like changing lenses on a camera. With a wide angle lens, a person standing in front of the camera is seen as rather small and insignificant in a wide view of his or her whole environment. With a telephoto lens, the individual will be seen very clearly in detail, but most of his or her environment will disappear. Using a normal lens, one can see the person and his or her interaction with his or her environment, but neither the person nor the environment will be seen in as much detail as with the specialist lenses. We need all three views to try to understand fully what is there.

In this section, I have discussed different theories of learning and their relevance to my study. In the next section, I consider the relationship between emotion, identity and cognition.

2.3 The relationship between emotion, identity and cognition

Traditionally, emotions have been seen as separate from cognition,

> respectable scientific accounts of cognition fail to include emotions and feelings in their treatment of cognitive systems. .... emotions and feelings are considered elusive entities, unfit to share the stage with the tangible contents of the thoughts they nonetheless qualify (Damasio, 1996, pp 158-9).

Emotions have been seen as stemming from the body, which has been viewed as inferior to the mind, 'dichotomous mind/body schemes assign emotions to the negatively valued body as part of the devaluation of immediate sensuous experience.' (Lave, 1988, p 182.)

Higher level thinking, on the other hand, like mathematics, has been seen as solely the province of the mind, as cold, irrefutable logic, having nothing to do with feelings, intuition or expression, 'mathematics is presented as a supreme example of the triumph of reason over emotion' (Burton, 2001, p 596). 'Correspondingly, higher cognitive functions are presumed to be further away from the body and from "intuitive, concrete, context-embedded" experience.' (Lave, 1988, p 182.)

But researchers are now finding that emotion is inextricably related to thinking, 'Cognition in action is by nature fused with feeling since it cannot be separated from the expression and creation of value.' (Lave, 1988, p 182.) Within the field of educational research, Hodkinson (2004) asserts that 'work and learning ... is *(sic)* embodied, being emotional, social, cultural and partly tacit.' (p 23). Burton agrees, 'I understand learning as being a product of (the) interplay between affect and cognition within social contexts.' (2004, p 360.) 'There are a number of reasons, it seems, to give up categorizing knowledge, thinking and feeling in the image of a person and world stringently divided.' (Lave, 1988, p 182.)

> When we approach the problem of the interrelation between thought and language and other aspects of the mind, the first question that arises is that of intellect and affect. Their separation as subjects of study is a major weakness of traditional psychology. (Vygotsky, 1986, p 10.)

In real-life situations, decisions are made by a combination of rational and affective processes, so that feelings are crucial elements of decision-making (Damasio, 1996). As a neurologist, Damasio has treated patients with damage to the pre-frontal lobes of the brain, and who have lost their ability to feel emotions but have retained all other aspects of intelligence, as demonstrated by intelligence tests: perceptual ability, past memory, short-term memory, working memory, new learning, language, arithmetic, attention, and logical competence. He found these patients unable to make appropriate decisions in their lives: in consequence their lives fell apart. He discovered that his patients used totally rational strategies like those advocated by Plato, Descartes and Kant, but these were ineffective because they were too time-consuming for most day-to-day decisions. 'Deciding well also means deciding expeditiously, especially when time is of the essence, and, in the very least, deciding in a time frame deemed appropriate for the problem at hand.' (1996, p 170.)

He suggested that undamaged people do not make everyday decisions like this: they work with their reason and their emotion together (*Ibid,* pp 170-171). Decisions are mediated by 'gut feelings' towards or against possible solutions (Damasio, 1996). He labelled these feelings 'somatic markers' (*Ibid,* pp 177): the body reacts to the outcomes of possible decisions by remembering previous similar situations it has encountered.

> ... most somatic markers we use for rational decision-making probably were created in our brains during the process of education and socialization, by connecting specific classes of stimuli with specific classes of somatic state. (*Ibid,* p 177).

These somatic markers cut down the number of options to be considered and therefore aid decision-making in an appropriate time-scale (*Ibid*).

The interplay between the evolutionarily early part of the brain and the parts which are more developed in humans, e.g. the pre-frontal lobes, enable us to be conscious of our emotions and to remember them. These then become 'secondary emotions'. 'Contrary to traditional scientific opinion, feelings are just as cognitive as other percepts.' (*Ibid* p xvii.) The prefrontal lobes of the brain deal with both high level reasoning and with secondary emotions (Damasio, 1996). In undamaged people, both reasoning and feelings are invoked in problem-solving and work together. 'I suggested that feelings are a powerful influence on reason, that the brain systems required by the former are enmeshed in those needed by the latter.' (*Ibid* p 245.)

Lave reached the same conclusion, 'A problem is a dilemma with which the problem solver is emotionally engaged.' (1988, p 175.) In mathematicians' descriptions of their own research processes, Burton found that pleasure in getting a result was an important aspect of doing the work, 'You gain pleasure and satisfaction from the feelings which are associated with knowing.' (1999, p 134.)

In Maths education, two important relationships between emotion and cognition are motivation for learning and maths anxiety.

2.3.1 Motivation for learning and its relationship with identity

According to the theory of situated learning (Lave and Wenger, 1991), the motivation for learning for a newcomer to a community of practice is to be able to participate more fully in the community. 'Acceptance by and interaction with acknowledged adept practitioners make learning legitimate and of value from the point of view of the apprentice.' (Lave and Wenger, 1991, p 110.) Along with knowledgeable skills and discourse, experienced participants in a community of practice will have adopted the values of that community, as a part of their identity as members of the community (*Ibid*). Newcomers become progressively more competent in the activities, take on more responsibility, and identify more with the values of the community (*Ibid*). Eventually they become full members of the community, able to do all the things the community does and fully identifying themselves as members of the community.

> Moving towards full participation in practice involves not just a greater commitment of time, intensified effort, more and broader responsibilities with the community, and more difficult and risky tasks, but, more significantly, an increasing sense of identity as a master practitioner (*Ibid,* p 111).

Marr and Helm (2002) created a model of holistic numeracy competence with a group of experienced adult numeracy teachers in Australia. The model is represented by a diagram which consists of a rectangle formed from seven irregular shaped jigsaw pieces representing: transfer and application, autonomy and independence, the Task Process Cycle (see Section 2.5.6.2), skills and knowledge, awareness, confidence, and personal connections. Marr and Helm (2002) suggest that these different aspects of learning are closely interrelated. Together they enable students to change their identities from those of people who cannot do numeracy to people who can. Marr and Helm (*Ibid*) emphasised that skills and knowledge alone are not enough to create competence in numeracy. They recognised that affect is as important as cognition. Students need to develop awareness of their own learning processes and confidence, which will allow them to engage fully with tasks, and lead on to independence and autonomy in their learning (*Ibid*). They also need to be motivated to learn (*Ibid*). Part of their motivation is to know how their learning will be useful outside of the classroom (*Ibid*). Marr and Helm eschew breaking up learning into little bits and emphasise the holistic nature of numeracy.

2.3.2 Maths anxiety

Buxton (1981), who investigated maths anxiety, found contrasting feelings, a state of panic, in some people at the very sight of anything mathematical, even numbers. The participants in his study, who were selected for their lack of confidence in doing maths, experienced a turbulence in the mind or mind in chaos, sometimes accompanied by violent physical activity, such as flailing about when drowning, followed by a sense of paralysis, a freezing of the mind, linked often with physical retention and rigidity. Buxton found that this feeling of panic became particularly acute when the participants felt under pressure to perform mathematics at speed or in public. They felt that they would be judged wrong as people if they produced an incorrect answer (*Ibid*).

The people in Buxton's study (*Ibid*) believed all or some of the following ideas about maths. That it is:

1. Fixed, immutable, external, intractable, and uncreative.
2. Abstract and unrelated to reality.
3. A mystique accessible to few.
4. A collection of rules and facts to be remembered.
5. An affront to common sense in some of the things it asserts.
6. A time-test.
7. An area in which judgements not only on one's intellect but on one's personal worth will be made.

8. Concerned largely with computation (Buxton, 1981).

To illustrate how widespread maths anxiety is, Buxton described a situation in which he frequently found himself:

> The pretence of a shudder that a person gives when they hear you are a mathematician, accompanied by a laugh meant to indicate the reaction is only in fun. ... Similarly the person's backing away, with hands raised as if to ward you off, may not exactly mean that he regards ability in maths in the same light as a social disease, but it does imply that one should not parade it if one wishes to win friends and influence people. ... The spoken response seldom varies. When one states an interest in maths it is rarely met with the invitation, "Oh, how interesting, do tell me more." Rather there is the fairly obvious "let's talk about something else" ploy expressed in one of two ways. There may be the defensive "Oh, I was never good at mathematics", or, alternatively, we have the surface compliment: "You must be very clever", said with the evident accompanying meaning that one may also be a threat and a bore (Buxton, 1981).

Buxton suggests that the aim of providers of maths education should be to promote the following attitudes to maths.

That maths is:

1. Experimental, exploratory and creative.
2. Abstract at times but often directly related to the most practical of problems.
3. Open to all, but (as with all areas of study) to be penetrated more deeply by some than others.
4. A network of consistent relationships, easily remembered when understood.
5. Always reconcilable with the internal logic of the mind.
6. A contemplative subject requiring concentrated and undivided attention at all times but almost never needing to be done in haste.
7. An area in which judgements on one's ability should carry no more weight than in other studies.
8. About relationships in general. (Buxton, 1981.)

These ideal attitudes to maths are in contrast to the attitudes that Buxton actually found amongst the participants in his study, that I reported above. He found that by having an opportunity to talk about their feelings about maths and to understand the origins of them, the participants were able to overcome their anxieties and learn some maths.

A study of people's use of mathematics in everyday life (Sewell, 1981) for the Cockcroft Committee (DES/WO, 1982) (see Section 2.4.4.1) also revealed maths anxiety. This apparently widespread perception among adults of mathematics as a daunting subject pervaded a great deal of the sample selection; half the people approached, as being appropriate for inclusion in the sample, refused to take part (Sewell, 1981).

> There was ... a widespread reluctance to be interviewed about mathematics. Both direct and indirect approaches were tried, the word 'mathematics' was replaced by 'arithmetic' or 'everyday use of numbers', but it was clear that the reason for people's refusal to be interviewed was simply that the subject was mathematics. ... Evidently there were some painful associations which it was feared might be uncovered. (Sewell, 1981, p 10-11.)

From the responses of the adults who did take part in her study, Sewell suggested that the causes of what she calls 'inhibition about using mathematics' (*Ibid*, p 72) were 'teachers' attitudes, the formality of much maths teaching, the seeming lack of relevance of mathematics to everyday contexts, fear of the subject, literacy problems, gaps in schooling, and parental expectations' (*Ibid*, p 72).

Evans (2000) asked his students to solve the problems that Sewell (1981) used in the second part of her study (see Section 2.4.4.1) and then to talk about the contexts of the problems, which were intended to be everyday situations. He found that the students had emotional reactions, some of which were explicitly expressed and some of which were implicit in their conversations. These reactions affected their ability to solve the problems.

In this section, I have considered literature which relates emotion and identity to cognition and found that while higher level thinking, particularly mathematics, has traditionally been considered as totally divorced from emotion, recent writers in fields as diverse as neurology, socio-cultural studies and mathematics education have demonstrated the connections between mathematical thinking, emotion and identity. I found that my participants' problem-solving was affected by their emotions and that these were sometimes implicit and that they were closely inter-related to their identities. I discuss this aspect of problem-solving in Chapter 6.

2.4 Everyday cognition

2.4.1 Introduction

Lave found that in the positivist epistemology of traditional psychological studies, everyday practices are viewed as primitive and inferior to scientific thought and professional practices (1988). Types of thinking form a hierarchy with scientific understanding at the top, lay knowledge of science in the middle, and what 'jpfs' (just plain folks) (*Ibid*, p 4) know at the bottom. This latter everyday cognition is seen as functional, non-scientific, lower class, primitive, often female or childlike:

> In the functionalist view the label "everyday" is heavy with negative connotations emanating from its definition in contrast to scientific thought. Its customary use encompasses the unmarked, unsung category of humble domestic activities and their associated social roles (e.g. housewives, running errands) (Lave, 1988, p 14).

But, in Lave's view, 'everyday cognition' is not an inferior kind of knowledge:

> "Everyday" is not a time of day, a social role, nor a set of activities, particular social occasions, or settings for activity. Instead the everyday world is just that: what people do in daily, weekly, monthly, ordinary cycles of activity. A schoolteacher and pupils in the classroom are engaged in "everyday activity" in the same sense as a person shopping for groceries in the supermarket after work and a scientist in the laboratory. It is the routine character of activity, rich expectations generated over time about its shape, and settings designed for those activities and organised by them, that form the class of events which constitutes an object of analysis in theories of practice (Lave, 1988, p 15).

Nevertheless, in spite of its lowly status, everyday cognition is seen as something that the professionals should control and assess: there is 'a widely shared belief that "scientific thought" is a proper yardstick with which to measure, diagnose and prescribe remedies for the "everyday thought" observed in experiments and schooling' (*Ibid*, p 4).

Lave (*Ibid*) found that, traditionally, most work on cognition has been laboratory based, with the assumption that the findings will be applicable outside the laboratory. Studies are constructed on the scientific model, but contextualised as apparently related to everyday life (*Ibid*). However, the real world is far more complex than the psychology laboratory: problems do not arise, and are not solved, in isolation; they are part of the complex web of social relationships and our whole environment (*Ibid*). We use our past experiences to predict what will probably happen, but we have to modify constantly our predictions in the light of what actually happens (*Ibid*). It is only recently that everyday practices have begun to be seen as a valuable, and therefore legitimate, field of study and as significant as abstract thinking (*Ibid*).

2.4.2 Logical thinking

In a study of rural communities in Uzbekistan and Khirgizia, in the 1920s, it was found that people who had had some schooling were able to categorise objects, but people who had had no schooling did not reason in the same way (Luria, 1979). Instead, they used a situated system of categorisation, saying that an axe, a saw, a hammer and a log were all necessary for cutting wood. In whatever way the researchers asked the question, they could not persuade their subjects to make the distinction the researchers would make between the tools and the log: the subjects seemed not to be able to construct the abstract concept of a tool. 'Words for these people had an entirely different function from the function they have for educated people. They were used not to codify objects into conceptual schemes but to establish the practical interrelations among things.' (Luria, 1979, p 73.) The people's reactions were similar to those of young children reported by Vygotsky (1978): they started using one category, but switched to another in mid-task (Luria, 1979).

The unschooled respondents refused to say whether the conclusions of syllogisms expressed in familiar contexts, for example statements about bears, were true or false, saying that unless they were in the situation they could not tell (*Ibid*). Again the subjects with some schooling were able to perform these tasks 'correctly'. Luria (*Ibid*) concluded that education is essential to develop abstract thinking. An alternative analysis could be applied to this study, which would recognise schemes of categorisation and syllogisms as Western cultural practices, to which the unschooled Uzbekhis and Khirgizians had not had access. Instead of studying the way the Uzbekhis and Khirgizians solved the problems that they identified for themselves, Luria tested them on the kind of problem-solving in which he had been educated. He saw the situated way of thinking as inferior to abstract thinking. Presumably the Uzbekhis and Khirgizians did not see themselves as deficient. Abstract thinking probably does not help much when it comes to chopping firewood: it requires manual skill and visual-spatial ability. Abstract thinking might be useful for organising the work. On the other hand the successful tracking of bears (if that's what the Uzbekis and Khirgizians did) must require some abstract thinking, trying to anticipate the behaviour of the bear, deduced from previous experiences and accounts of others' experiences.

Luria (*Ibid*) did point out that there was an Uzbeki 'high culture' (*Ibid*, p 60) which had produced excellent artistic and scientific work, but that the previous feudal society had only made this available to the privileged few. Luria concludes that the developing universal education system, which was being set up in the Soviet Union at that time, was necessary for the progress of these people. Of course one has to look at this in a historical light: this was a time in the Soviet Union when people thought that they were building a new and better kind of society: Vygotsky and his followers were creating a new Marxist psychology to serve the new education for this society. In the Soviet Union there was a period of rapid social change where agricultural land was being organised into collective farms. People's working situations were changing so that their existing skills and knowledge would need to be transformed.

More recently, Western (and therefore presumably schooled) participants were found to be able to solve logical problems of the form, *if – then*, using statements with a context of social relationships like permission, prohibition, or promise, for example, 'Passengers in the front seat of a car must wear seat-belts.' (*If* you sit in the front seat, *then* you must wear a seat-belt.) They found abstract non-contextual problems much more difficult (Cheng and Holyoak in Nunes, Schliemann and Carraher, 1993, pp 140-145).

2.4.3 The socio-cultural context

2.4.3.1 Social relationships

> Prescriptions recommending calculation to achieve utility, rationality and objectivity are eclipsed in practice by more urgent values concerning the production and reproduction of ongoing activity and social relations (Lave, 1988, p 141).

The maths in everyday life was constructed socially within the contexts in which it was used in Lave's study (1988). The transformation of quantitative relations (or calculation) was only one element in the multiple ongoing activities that constituted everyday life (*Ibid*). Dilemmas were structured in, for example, grocery shopping rather than mathematics (*Ibid*). The quantitative relations were not confined within the boundaries of mathematics, but had closer relationships to other things, like providing meals for the family.

> ... it appears that in practice, relations among arithmetic elements and other kinds of concerns in the world are often equal to, or more important than, the arithmetic relations among those same elements, and relations of quantity are merged (or submerged) into ongoing activity (Lave, 1988, p 120).

Social relationships were crucial to the activities of candy-selling children, in the streets of Recife, Brazil (Saxe, 1991). The children were helped by their families and by the clerks in the wholesalers to choose which sweets to buy and sell and how much to charge. They priced the candy at a convenient currency note or coin, it might be 3 sweets for 10 cruzeiras, and so that they would sell the whole box for approximately twice the wholesale price. Then they would go to their pitches and sell the candy. Many of the customers also helped the children by buying sweets and helping them calculate the change. But there was also competition between children over the best selling pitches. So the whole buying and selling process was structured by social relationships.

In a study of the real life sharing of the cost of a pizza between friends, Johnston, Baynham, Kelly, Barlow and Marks (1997) found that the methods used by their participants were more dependent on social structures than mathematical knowledge: types of friendship, the amount of money they earned and family responsibilities. The researchers asked their participants how they would actually do it:

> Say you went out with some friends, and you had a pizza and you're going to share the costs. When people do that they are going to work out how much they are going to pay in different ways. So say it was you and you went with two friends, and the pizza cost 16.90 dollars, how do you think you would pay for it? (*Ibid*, p 93).

The participants came up with a wide range of responses: one participant said he worked in a pizza shop and could make free pizzas whenever he liked; others said they would take it in turn with their friends to pay; some said they would pay for the group if they were the one with money that day; some did an approximate calculation; some did a rougher estimate to a convenient currency note and said one person would pay the extra; but others did not trust their friends to reciprocate and tried to work out the shares precisely. These varied responses show that in real life situations there is no one correct solution to such a problem. Whether a solution is satisfactory depends on the point of view of the participant.

2.4.3.2 Feelings and values in everyday problem-solving

Lave found that, 'Generative, system-maintaining, value-driven, multilevel activity seems a better analytic description of relations of quantity in practice.' (1988, p 141.) Decisions were often based on qualitative factors, rather than quantitative reasons. In Lave's (*Ibid*) study of how people manage their money, she found that conflicts between the interests of the individual and those of the family were resolved by moral prohibitions, which reflected the values within the family of promoting the well-being of the collective. 'Since quantitative relations, embodying value directly, bear direct relations with aspects of dilemmas that aren't quantitative, most dilemmas which involve relations among quantities are not well-formed arithmetic problems' (*Ibid,* pp 175-6). Social relationships, feelings and values provided the structure and meaning within which dilemmas were formulated and resolved (*Ibid*). So, in the supermarket, Lave's participants might describe how they would behave like good consumers, comparing products to determine best buys, and then buy something else for affective reasons (*Ibid*). They shared society's traditional view of problem-solving: they claimed to be behaving rationally because they belonged to a society that valued this (*Ibid*). In my study, I found that the participants' accounts of their problem-solving were logically structured, but that the participants frequently expressed feelings about their problem-solving or used emotive terms to describe their experiences: their feelings clearly influenced how they constructed and resolved problems. I explore this issue in Chapter 6.

2.4.3.3 Learning through taking part in activities

In Saxe's (1991) study of child candy-sellers, the older children, who had been selling candy longer, were better able to handle currency, to give change, and to decide on the best boxes of candy to buy and to price the sweets. Saxe concluded that the children had learnt these calculation skills through work rather than through schooling.

In their study of carpenters in Brazil, Nunes' et al (1993) found that the more experienced workers in the carpentry workshop were more able to do the necessary calculations than the apprentices, even though the latter had had more schooling. The practice in the workshop was for the experienced carpenters to draw up lists of the measurements of the pieces of wood for making the furniture. The apprentices were then required to cut the pieces on the list. The researchers found that the less experienced apprentices could not calculate appropriately the amount of wood required to construct a bed, but the more experienced apprentices were much better at doing it. Therefore it is probable that apprentices learnt the maths they needed gradually, through their experiences of using the carpenters' measurements of the pieces of wood to cut, rather than using any maths learnt at school. 'It is not only in schools that we learn mathematics. Research shows that people with restricted schooling come to master mathematical operations.' (Schliemann, 1999, p 20.). Everyday activities 'seem to promote the development of mathematical understanding, believed to be accessible only through formal school instruction' (*Ibid*).

2.4.3.4 The invisibility of the maths in everyday activities

Harris (1991) found that inquiries into the maths required for working in industry have often concentrated on filtering the mathematical concepts and procedures out of work practices. This practice is based on the traditional view that maths is best taught in an abstract form, and can then be applied back into work situations (*Ibid*) (see Section 2.2.3.3). But structuring inquiries in this way predetermines the nature of the findings: that most work requires a knowledge of the four rules of arithmetic, applied to whole numbers, fractions, decimals and percentages (*Ibid*). In analyses of the mathematics needed for work, it has always been assumed that only arithmetic is required (*Ibid*). These studies ignored spatial relationships, which are an important part of the maths used in work (*Ibid*).

Harris (1997b) also investigated the mathematics used by women in their work, both historically and worldwide. She toured the world with an exhibition she constructed, which explored mathematics in women's craft work. She collected more examples, ideas and feedback from visitors to the exhibition. She found that traditional women's craft activities, such as spinning, weaving, knitting, sewing and embroidery, require an understanding of spatial relationships, as well as number, that has not been recognised, and concluded that this was because they are women's activities (*Ibid*).

An examination of the work of airline pilots, nurses and bank employees found mathematics underlying many practices, but unrecognized by practitioners (Hoyles, Morgan, and Woodhouse, 1999). Everyday cognition includes our knowledge of language, quantities, space, time, movement, and shape as well as sense making resources that we express by making inferences, judging conclusions, establishing categorizations, using metaphors, and assuming generalizations (Carraher, Schliemann. & Nemirovsky, 1995). Coping with new and complex events is also part of everyday experiences (Schliemann, 1999).

2.4.3.5 The use of tools

Tools are important attributes of the socio-cultural contexts of problem-solving (Saxe, 1991; Lave and Wenger, 1991; Masingila, 1993) (see Section 2.2.3.2). Masingila (1993) found that carpet-layers used trundle-wheels, measuring tapes, six-sided drafting rulers with scales for converting measurements on blueprints done to different scales. They made sketches to help them calculate and employ the mathematical concepts of 'measurement, computational algorithms, geometry, and ratio and proportion' and the mathematical processes of 'measuring and problem-solving' (*Ibid,* p 8). I would not describe 'computational algorithms' as 'mathematical concepts', rather as mathematical tools. I also found tools were important in problem-solving. In Section 5.2.5.3, I identify different categories of tools that were used in my study: abstract/cognitive, environmental, both concrete and non-concrete, social and personal.

Calculators are important tools in paediatric and intensive care wards (Hutton, 1998a), although they are not used in most areas of nursing: mental health nursing, nursing patients with learning difficulties or on general adult wards (*Ibid*). In paediatrics, nurses carry their own calculators and use them for all calculations, simple and complex (*Ibid*). The most diverse calculations are carried out in neo-natal units (*Ibid*). Doses of drugs, fluid input and output and intravenous nutrition have to be calculated according to babies' weights, which are constantly changing (*Ibid*). Although these calculations are the responsibility of doctors, they are checked by nurses (*Ibid*), both professions using calculators (*Ibid*). In intensive care units, either one calculator is provided for each bed or all nurses carry their own calculator (*Ibid*). Nurses know whether the answers they get are within a sensible range through their experience (*Ibid*).

Lave (1988) found that people sometimes created their own tools to solve everyday problems, for example, using the design on a glass to measure a quantity of liquid for a diet. I also found that my participants invented tools to assist them in their problem-solving. I explore this further in Section 2.5.3.5.

2.4.3.6 Methods of problem-solving

In observations of everyday life, for example, people doing their normal grocery shopping, or members of a Weightwatchers club preparing meals in their own kitchens, the participants generated their own dilemmas and used a wide range of strategies to resolve them to their own satisfaction (Lave, 1988). They did this in a number of different ways, according to the actual numbers involved and how easy they were to manipulate with each other: by dividing and multiplying; by comparing the difference in weight with the difference in price and deciding whether one was worth the other; by finding two portions with the same weight and comparing their prices; by considering the storage space required for a larger item; by deciding whether they wanted larger or smaller portions; by considering how long the food would keep; by considering whether they preferred one item over the other (*Ibid*). Often participants made several attempts before resolving their dilemmas (*Ibid*). They were able to check whether partial or interim solutions were consistent with reality and whether they were likely to reach a satisfactory answer using their chosen method (*Ibid*). Then they were able to make another attempt until they were satisfied, or to abandon the problem as not being worth spending more time on (*Ibid*). In experimental conditions, where the same participants were asked to decide on the 'best buys' between pairs of grocery items, although they were presented with problems, the participants still used a range of strategies, appropriate to the situation they were in and did not always try to find a precise answer (*Ibid*). These findings are in contrast to a study undertaken by Capon and Kuhn (1979) who set up a table outside a supermarket and asked shoppers to perform best buy calculations on a number of pairs of items, using paper and pencil. The results were dramatically different from Lave's (1988): only 44% answers were correct in the Capon and Kuhn study (1979), compared with 93% in Lave's study (1988). She asserts that in the Capon and Kuhn study (1979) the participants were given school maths questions contextualised as if they were everyday maths and the participants treated them like school maths questions.

Masingila (1993) studied the maths used in carpet-laying where measurement is a fundamental activity. There were two different jobs: estimator and installer. The estimator measured the dimensions of the floor and calculated the amount of carpet required; the installer measured the floor to check the estimator's measurements. Masingila (*Ibid*) emphasised that at no time did the estimators and installers calculate the area of the room being carpeted: they measured the dimensions of the room and calculated the amount of carpet required, i.e. the number of rolls or the size of the piece to be cut off a roll, or the number of carpet tiles. Inevitably the carpet had to be cut to waste. The customer paid for the waste as well as the fitted carpet: the area of the room was therefore irrelevant. The actual maths that the carpet-layers used is more complex: it required the comparison of the dimensions of carpet required (including waste) by placing the carpet in the two different orientations square with the room, and with the following constraints.

> Constraints I observed include that: (a) floor covering materials come in specialised sizes (e.g., most carpet is 12' wide, base (vinyl piece glued around the perimeter of a room) is 4' long, most tile is 1' by 1'), (b) carpet pieces are rectangular, (c) carpet in a room (and often throughout a building) must have the nap (the dense fuzzy surface on carpet formed by fibers from the underlying material) running in the same direction, (d) consideration of seam placement is very important because of traffic patterns and the type of carpet being installed (e) some carpets have patterns which must match at the seams, (f) tile and hardwood pieces must be laid to be lengthwise and widthwise symmetrical about the center of the room, and (g) fill pieces for both tile and base must be six inches wide or more to stay in place. (Masingila, 1996, p 7.)

The placement of the seam had to be weighed against the cost implications of running the carpet in different directions.

When installing carpet tiles, the installer calculated the position of the centre of the room by dividing the dimensions by two, to calculate the length or width of the filler pieces of tile at the edges. If the filler pieces would be smaller than half a tile, then the tile in the centre of the room must be shifted 6 inches in one or both directions, so that the spaces left over from the whole tiles became more than 6 inches wide or long.

Nunes, Schliemann and Carraher (1993) compared how people use maths at work with school maths education in a study in Brazil. They concluded that school learning of maths was totally irrelevant to work situations. The researchers constructed problems based on everyday activities: market traders calculating prices, fishermen calculating the price of caught fish from the retail price of prepared fish, building site foremen using scale plans to calculate sizes for construction, carpenters calculating the timber required for building wooden beds, and farmers calculating the numbers of plants needed for pieces of land of particular sizes. In some cases, the authors made variations from normal practice, and compared the methods the participants used with those used by school children doing similar problems. In most cases workers performed better than students with similar amounts or more schooling (*Ibid*). The calculation methods the workers used were totally different from those used by the students: the workers used mainly oral methods, with the context for the calculations kept constantly in mind (*Ibid*). This is in contrast to the methods taught in school: extracting the numbers and operations, performing calculations on them, then applying the answers back to the context, with an emphasis on using written algorithms (*Ibid*). The students attempted to use these methods, but often did not remember them well (*Ibid*). Nunes et al (*Ibid*) found that their subjects were far less likely to make mistakes in the work situation where the calculation values were meaningful to them, than in a school type of situation.

2.4.3.7 Control of the problem

Lave (1988) re-named problem-solving as 'the resolution or dissolution of dilemmas', which were generated from disjunctions, conflicts and contradictions that occurred in the course of people being involved in activity. '"Problems" were dilemmas to be resolved, rarely problems to be solved' (1988, p 20). The resolutions to dilemmas may be partial and shifting: often the generation of the problem and the solution happened together (*Ibid*). 'People do not have a math problem unless they have a resolution shape - a sense of an answer and a process for bringing it together with its parts' (*Ibid,* p 19). There were no correct solutions: 'a dilemma has no factual solution, no general, in principle, correct answer. It is a matter of conflicting values and viable alternatives, which are neither right nor wrong, and none of which is entirely satisfactory' (*Ibid,* p 139).

During problem-solving in real situations, the participant maintained control of the situation: they had generated the dilemma themselves and they decided how to resolve it (Lave, 1988). They did not necessarily require a precise answer: an idea of something being larger or smaller was often enough (*Ibid*). It was therefore not always necessary for the participants to do exact calculations (*Ibid*). But to diagnose this lack of precision as due to limitations of the participants' processing ability, as has been done in many studies, 'would offer an absurdly impoverished account of the structuring of these relations' (Lave, 1988, p 120).

2.4.3.8 Routine problem-solving

In problem-solving in everyday life, for most circumstances, there are accepted procedures that people learn by being present when more experienced workers use them. Occasionally an unusual set of circumstances presents a worker with a problem that she must solve by using her experience and adding something new to it.

Masingila (1996) found that most of the problems that the carpet-layers solved were routine, but that there were exceptions, where there were 'unfamiliar constraints (e.g. a post in the middle of the room) and irregular shapes of rooms' (*Ibid*, p 8). In those non-routine cases, the carpet-layers had to use a 'process of coordinating previous experiences, knowledge and intuition in an effort to determine an outcome of a situation' (*Ibid*, p 8).

Lave (1988) found that the participants in her study viewed their everyday life activities, for example grocery shopping, as routine, but there were in fact variations between different incidents. Rather than following routines, her participants improvised in a complex way to reproduce, change or transform the activity (*Ibid*).

2.4.4 Surveys of adults' numeracy 'abilities' in everyday life

In this section, I discuss two surveys which have attempted to measure adults' use of mathematics in their everyday lives: Sewell's (1981) investigation into the Use of Mathematics by Adults in Daily Life, which informed the Cockcroft Report (DES/WO, 1982); and the numeracy part of the National Child Development Survey by Bynner and Parsons (1997) (also a study of adults), which informed the Moser Report (DfEE, 2000).

2.4.4.1 Sewell's investigation for the Cockcroft Committee

A study (Sewell, 1981) was conducted for the Cockcroft Committee (DES/WO, 1982) (see Section 2.4.4.1), to ascertain what maths adults use in their everyday lives, their levels of competence and their reasons for avoiding maths. Sewell (1981) reported that 'there seems to have been very little work done to ascertain what mathematical skills are actually used by adults outside their place of work.' (*Ibid,* p 3.) The study was carried out in two stages. In the first stage, 107 adults were given a first interview, in their homes, or community centres they attended, where they were invited to discuss some commonly found situations, with which they were familiar. The stimulus for the discussions were twenty-two prepared questions:

(1) In the supermarket, how do you know that you have enough money to pay for the items in your trolley?

(2) In a pub (fish and chip shop, restaurant), do you work out the cost of what you want before you order?
(3) When shopping for one or two items, do you check the change?
(4) When buying curtain material (carpet, wallpaper), do you measure what you need?
(5) When you cook, do you weigh the ingredients? If not, do you weigh anything?
(6) If you see something you want in the shops and it's marked '10% off', do you work out how much you would save? (If no) Could you if you wanted?
(7) When you get a repair bill, do you look at the VAT (Value Added Tax) to see you haven't been overcharged? (If no) Could you if you wanted?
(8) When shopping from a mail order catalogue, do you work out any percentages?
(9) Do you know how much more your loan/hire purchase costs than if you had paid cash?
(10) Are you charged any interest on your Access/Barclaycard?
(11) Do you write out a budget or your accounts?
(12) Is there a calculator you could use if you wanted? If so, do you use it?
(13) Do you look at timetables?
(14) Do you use maps?
(15) Do you fill in a tax return?
(16) Do you pay the electricity bill?
(17) Do you pay the rent or mortgage for your home?
(18) Do you keep money in a Bank, Post office, Building society or other?
(19) Do you enjoy filling in forms?
(20) Can you tell me of anything that you do in your spare time that involves numbers?
(21) *(Omitted.)*
(22) Do you enjoy working with numbers?
(23) How well would you say you can manage in everyday situations where numbers are involved? (Sewell, 1981, pp 13-16.)

The participants were not asked to do any calculations, 'By describing their usual behaviour in any of these situations, the interviewees gave some indication of their functional numeracy skill without having to do any 'sums'.' (Sewell, 1981, p 8.) These questions are interesting because they did not require calculations; they only asked the respondents to describe their reactions to situations. For example, in the first question, Sewell recognised that for a person to get to the checkout till in a supermarket, without enough money to pay for the items in her or his trolley, was a potentially emotionally loaded situation. Only one of Sewell's respondents said that they would return the goods to the cashier. Her other respondents described a wide variety of methods for estimating or calculating the total. But a significant number (20 out of 107) said that they would take more money than they needed to the supermarket or pay by cheque. These were good questions therefore to find out what people actually do in their lives.

The list of questions is heavily biased towards spending money. The study was not intended to cover work-related tasks, so perhaps pay-slips, or rates of pay were considered irrelevant. Only one question concerns time, the use of timetables. Clock-time, calendar time and years do not feature. Measurement and spatial relationships, as map-reading, also occur in only one question each. Area, weight and volume could be involved in answers to the questions on cooking and what people do in their spare time. In answering Question 20 (*Ibid,* p 16), the participants mentioned the following activities in which they used maths, which would involve measurement of length, volume or weight, or spatial relationships:

> ... 'Do-it-yourself' work, ... car running costs, planning household alterations, ... sewing, dressmaking, needlework, crafts, embroidery, upholstery, knitting, cooking, diet, wine making, pottery (glazes), gardening, photography ... (*Ibid,* p 16).

I decided to base the questions that I would give to the participants in the Everyday Maths Group on some of Sewell's (1981) questions. I did not want to use her actual questions, because of their bias towards spending money: I wanted to inquire about a wider range of activities. But I decided to use the form of Sewell's questions: open questions asking people what they actually did in their lives, rather than closed questions narrowly focused on calculations.

Sewell (1981) concluded from this first part of her study that her participants' 'use of mathematics ranged from literally nothing to a high level of competence' (p 17). This conclusion depends on her concept of the use of mathematics. I find it hard to believe that there are any adults in British society, except those with learning disabilities, who do not do some quantitative and spatial problem-solving, even if this is not done with precision. Adults use clocks and calendars, handle money and have a sense of number, size and spatial relationships, which they use in their everyday activities.

Sewell (1981) found that there was no correlation between her participants' maths education and their perceptions of their use of maths in everyday life. She categorised her respondents in terms of their stated level of difficulty in answering the percentage questions. More than a third of them (two thirds men and one third women) said that they were able to do these questions (nos. 6-10) without difficulty. Of this group, half had been successful at learning maths during their education, but the other half had left school with no maths qualification and, of these, half reported having difficulty with learning maths at school. Most of these participants were computer programmers, teachers or managers and used calculations in their everyday lives.

Another third of the participants, containing a preponderance of women, said that they could calculate 10% reasonably easily, but found calculating 15% difficult. Two thirds of this group had no mathematical qualification. They were teachers, nurses, cashiers and factory workers. The graduates were mainly arts graduates, who tended to have had difficulty with maths at school, had an antipathy to maths and were aware of their mathematical limitations. Many in this group did not use calculators and there was a possibility that they did not know how to.

The last third of the participants said that they never used percentages and did not weigh or measure, but they did budget and did use calculators. Almost all had left school at the minimum age. Most were drivers or labourers.

In the second part of her study, Sewell (*Ibid*) chose participants from the first part in particular categories: ten people from the first group, who said that they had difficulty with maths, plus two mathematicians, twenty people from the second group, of whom seven had maths qualifications, but seemed to be mathematically weak and had a lot of anxiety around maths and as many from the third group as were willing to be interviewed. The participants were asked twenty-two questions, of which eight required reading and interpretation, but no calculation, and fourteen required calculation. The contexts of the problems were realistic: Sewell used such things as a real map, a graph of the fluctuation of the price of gold, an electricity bill and a wages slip. However the questions were not realistic, in the sense that they had been constructed by Sewell, not the participants, and therefore did not necessarily reflect how they would construct them in their real lives.

Sewell (*Ibid*) claimed that the participants seemed to find the questions familiar, but it is hard to imagine that the majority of people read graphs of the fluctuation of the price of gold. As in the first part of the study, the questions were heavily weighted towards money calculations, and in particular percentages (15 questions), although this time there were three questions on wages, one on income tax and one on the rate of inflation. Of the other questions, four were concerned with the measurement of length, three with weight, three with volume, two with time and three with spatial relationships (some questions combined two or more of these categories). As well as attempting to do the calculations, the participants talked about their experiences, both of tackling, and avoiding, such calculations in their everyday lives and of learning, or not learning, maths at school.

Sewell (*Ibid*) concluded from her study that it was not easy to define the mathematical needs of adults in daily life, because how people met their needs depended on their mathematical skills. The mathematics her participants used varied widely, according to their individual life-styles, but each participant appeared to have only one method available to them for each question and these tended to be simple and somewhat clumsy. Skills like quick mental methods, estimation and easily obtained approximate answers were widely used. Many of the interviewees either could not, or would not, use a calculator. It was the respondents with 'limited mathematical ability' (*Ibid,* p 72) who used calculators 'confidently and competently' (*Ibid,* p 72).

How people met their needs also depended on their attitudes towards maths: many of Sewell's (*Ibid*) participants had negative attitudes towards maths (see Section 2.3.2), which, in some cases, had affected their careers. She concluded that 'it seems that an increased emphasis on teaching and learning through a functional approach, rather than on formal manipulation, would lead to improved mathematical competency amongst adults.' (*Ibid*, p 72.)

I decided not to use the questions that Sewell (*Ibid*) used in the second part of her study. I wanted to collect my participants' perceptions of the maths they used in their lives, and how they used it, rather than to find out if they could answer pre-set questions.

2.4.4.2 The National Child Development Survey

An investigation into the literacy and numeracy skills levels of adults was part of the latest stage in the National Child Development Survey (NCDS) (Bynner and Parsons, 1997), a longitudinal study of all the people born in England and Wales in a single week in 1958. The authors claim to have shown that seven million adults (about 20% of the adult population of England and Wales) lacked the basic skills required to function in everyday life. A 10% sample of the cohort, who were 37 years old at the time of the study, were given nine numeracy questions, which were intended to reflect everyday life. I shall examine one of these questions as an exemplar of all of them. It typifies not only the numeracy questions in that survey, but questions used in many surveys of adult numeracy, in learning materials for adults and young people and in tests and examinations. The question postulates an evening's home entertainment for six friends who hire two video tapes at £2.50 each and order a take-away pizza that costs £19.66. Respondents were asked 'What is the total cost? How much does each person have to pay?' (Bynner and Parsons, 1997, p 116). There is a fundamental difference between this pizza question, asked by Bynner and Parsons, and the one asked by Johnston et al (1997) (see Section 2.4.3.1). Johnston et al (*Ibid*) wanted to know how their participants actually worked out a problem in real life. Bynner and Parsons assumed that they knew how such a problem would be worked out and were trying to find out how many respondents could produce their ideal solution.

In real life, take-away pizzas are not made big enough for six people to share: they could not be safely carried on motor-bikes. According to leaflets put through my door, the largest take-away pizza is the Super 15", which costs between £7.50 and £11.50, depending on the toppings, and serves 2-4 persons. A group of six friends would therefore need to order at least two of these pizzas. The pizza in the NCDS test question (Bynner and Parsons, 1997) is not a real-life pizza but a mathematics problem pizza. Adults can recognise these kinds of problems as disguised school mathematics problems and perform accordingly (Lave, 1988, Nunes et al, 1993). One participant in the Johnston et al (1997) enquiry (see Section 2.4.3.1) asked if he was being asked a mathematics question or asked to say how he would really do it. He said he would approach the question in two different ways: for a mathematics question he would provide an exact answer, but in real life, everyone would contribute whatever money they had and each person's expenditure would even out over time.

Participants are likely to make far more mistakes doing such calculations in a test or interview than when they are faced with an authentic problem in a real situation (Lave, 1988, Nunes et al, 1993). Then they can choose from a whole range of strategies, try them out and assess whether they will give a satisfactory answer (Lave, 1988). They can use resources such as currency notes and coins to help them (*Ibid*). They would not feel self-conscious about trying to solve their problems because they would have posed them themselves (Lave, 1988). None of these strategies are possible in the test situation, where the problem belongs to the tester, not the person being tested. In real life, there is no one correct answer:

> ... a dilemma has no factual solution, no general, in principle, correct answer. It is a matter of conflicting values and viable alternatives, which are neither right nor wrong, and none of which is entirely satisfactory. [Lave, 1988, p 139.]

The other eight questions in the NCDS (Bynner and Parsons, 1997) are similarly problematic: they are over-structured and closed, in order to ensure that there is only one possible correct answer for each part of each question and many of them are unrealistic. None of them allows the respondents to solve the problems in the range of ways that would be available to them in their everyday lives. By structuring the questions in the way that they have, the authors have jeopardised what they purport to be finding out: whether adults can solve these kinds of problems in their everyday lives. What they are discovering is whether their respondents can do school mathematics problems. What the survey shows is that seven million adults have some difficulty in performing school mathematics in a test situation: it does not show what happens in their everyday lives.

There is a more fundamental problem about the National Child Development Survey (NCDS) (Bynner and Parsons, 1997). The basis on which it has been decided what are the skills and knowledge that adults need to know to conduct their lives effectively has not been stated. What has been done is first of all to assume that the maths used in everyday life can be worked out unproblematically. Then, that it is straightforward to find out whether people can do this mathematics by asking them to work out 12 simple closed problems in a testing situation. Then, the assumption has been made that people who do not pass this test are incompetent in their everyday lives. Lave (1988) and Nunes et al

(1993) have shown that adults, even those with little schooling, are very competent at solving problems within their everyday activities. Nunes et al (1993) showed a major discrepancy between real life everyday problem-solving and attempting school maths problems.

Bynner and Parsons (1997) correlate their findings on the literacy and numeracy part of the study with findings from the rest of the study which enquired about other aspects of the respondents' lives: their education, employment, including remuneration, health, both physical and mental, including self esteem and trust, size of family, housing, and involvement in public activities, including voting in elections. They conclude that,

> Those with literacy and numeracy problems had much more patchy careers; many more were unemployed at the time of the survey or out of the labour market engaged in child care. They had married or had children early, had large families, and experienced separation and divorce to a larger extent. They reported symptoms of physical and mental health problems to a greater degree. Their participation in public activities, including politics, was significantly lower than that of their counterparts (*Ibid,* p 17).
>
> ... the vicious cycle of disadvantage and marginalisation associated with basic skills problems continues through adult life. A lack of basic skills during adulthood is characterised by poor job opportunities, lack of further education and training, and a tendency towards a stressful personal and family life (*Ibid,* p 17).
>
> There were strong indications that the consequences of poor literacy and numeracy, inherited from bad education, compounded the problems that the NCDS cohort members faced as they moved through adulthood (*Ibid,* p 16).

This seems to me to be a dubious conclusion. Bynner and Parsons (1997) make questionable value judgements, such as denigrating having a large family and staying at home to care for them. They have also not considered whether some of their criteria, such as poor health causing missed schooling, may not have been the reason for the low levels of basic skills, rather than the result of them. Employers' use of literacy and numeracy tests as gatekeepers to work, when the questions may bare little resemblance to the skills required in a job (Harris, 1997b), result in people who are otherwise competent having less prospect of employment.

Bynner and Parsons (1997) recommended increased literacy and numeracy education for adults: 'the needs of adults in this area are as pressing as ever.' (p 17.) Their survey informed the Working Group chaired by Sir Claus Moser (1999), which made recommendations for the development of adult literacy and numeracy provision for adults, resulting in the government's Skills for Life Strategy (DfEE, 2000) (see Section 2.5.4).

Lave's (1988) and Nunes' et al (1993) investigations into the maths used by adults in everyday life pre-date Bynner and Parsons' (1997) study by nine and four years respectively, but were not used to inform the questions in their study. Perhaps this was because Lave's (1988) and Nunes' et al (1993) investigations were carried out in other countries, or perhaps it was because they were smaller in scale than the 10% sample of the cohort (n=1714), which Bynner and Parsons (1997) used. Another reason could be because Bynner and Parsons (1997) were funded by the government with the intention of them making recommendations about adult basic skills education, so that they were really less interested in how adults actually solve problems in their everyday lives than in showing their relationship to qualification levels.

I see it as important to investigate whether Lave's (1988) and Nunes' et al (1993) findings are applicable to Britain and whether they are pertinent to different areas of employment and everyday activities than those in their studies.

2.5 Maths and adult numeracy education

My research interests are focussed on the maths that adults use in their everyday lives. However, this topic has implications for the teaching of maths to adults, because of the emphasis that is put by policymakers on adults' use of maths in their lives outside education (DES/WO, 1982; DfEE, 1999; BSA, 2001; Hoyles et al, 2002) (see Section 2.5.4.3). Also, this study originally arose from my experience of teaching numeracy to adults. I am now therefore going to consider some aspects of adult numeracy education, which are relevant to my study.

2.5.1 The purposes of maths/numeracy education

Mathematics education began in Britain in the 1750s as mathematics for the marketplace and became institutionalised as school mathematics by the 1820s (Lave, 1988). By 1900, an ideology had developed, of school mathematics being applicable to everyday life (*Ibid*, 1988). Mathematics education has two purposes. One purpose is to introduce mathematics as a discipline to students, a few of whom will continue to study it for its own sake to a high level. The other purpose is to develop enough mathematical skill and knowledge in all other students, so that they can use it as a tool in other disciplines, at a range of levels, and in their everyday lives. Mathematics, National Curriculum for England (QCA, 1999) says that mathematics equips pupils with a uniquely powerful set of tools to understand and change the world. These tools include logical reasoning, problem-solving skills, and the ability to think in abstract ways. It also describes mathematics as a creative discipline that can stimulate moments of pleasure and wonder when a pupil solves a problem for the first time, discovers a more elegant solution to that problem, or suddenly sees hidden connections.

The Cockcroft Committee adopted the term 'numeracy' to mean 'an at-homeness with numbers and an ability to make use of mathematical skills which enables the individual to cope with the practical demands of his everyday life' (DES/WO, 1982, p11) and 'an ability to have some appreciation of information which is presented in mathematical terms.' (*Ibid.*) The committee added, **'Our concern is that those who set out to make their pupils 'numerate' should pay attention to the wider aspects of numeracy and not be content to develop merely the skills of computation.'** (*Ibid.*) (Emphasis in the original.) Their intention was that low achievers in maths should become numerate and they provided a list of topics: number, money, percentages, use of calculator, graphs and pictorial representation, spatial concepts, ratio and proportion, and statistical ideas. In spite of their statement about merely the skills of computation, the Cockcroft Committee (DES/WO, 1982) put the emphasis on these mainly non-contextualised basic mathematical topics, rather than the contexts outside of the classroom. These topics then went on to form the basis for the lower end of the Mathematics National Curriculum for schools (DES/WO, 1989).

In October 1996, an international conference was organised by the Institute of Education, University of London, 'to reflect on the mathematics which will be needed in future - by the "educated person", by the employee in an environment of constantly changing technology, and by the scientist - and how this may be achieved.' (Hoyles, Morgan, and Woodhouse, 1999, p 1.) Contributors were mathematicians, scientists, technologists, policy-makers, and educators coming from research, teaching, administration, industry and commerce. 'Different cultures, societies, and economic systems have different perspectives on the nature of mathematics and the purpose of mathematics education.' (Hoyles et al, 1999, p 1.) Mathematics education is called on to serve national economic needs. Historically, curricula have changed in response to changing perceptions of the needs of individuals and society and to political influences. Recently, there has been an overall democratisation of mathematics. Some contributors felt that developments in technology meant that most people would need very little mathematics in future. Others argued that for nations to develop culturally, economically, and democratically, their citizens will need to become more mathematically sophisticated. All agreed that these developments require innovation in mathematics curricula, including addressing how students feel about learning maths. 'The personal sufferings of learners of all abilities have left a legacy of failure and resentment.' (Hoyles et al, 1999, p 2.) A relatively convergent view emerged from the contributors of 'a mathematics curriculum built round the construction and interpretation of quantitative models', which reflects work practices and motivates learners. The question was raised: 'what is the "kernel" of knowledge, skills, and concepts that we should teach our students in order to exploit appropriately the new technology of the 21st century?' (Hoyles et al, 1999, p 3.)

2.5.2 Maths education as social practice

Psychology and mathematics education share a common history and social context: their practitioners form an hegemony where mathematics is seen as an academic discipline, a career, and a body of knowledge (Lave, 1988). The complex networks which link the academy and schools mean that they share a common view of cognition and of mathematics (*Ibid*).

Harris (1997b) suggests that while purporting to be value free, mathematics plays a powerful social role in politics and economics and in classifying individuals and allowing or denying access to further and higher education. Western ideas of what constitutes mathematics and how it should be taught have been spread across the world in a remarkably homogenised form (*Ibid*, 1997b). Mathematics education has been gendered: two thousand years of Christian education and social conditioning in the UK has positioned most women as unable to learn mathematics (*Ibid*, 1997b). Until very recently, schools restricted most girls' access to mathematics and made them learn needlework instead (*Ibid*, 1997b). Learning materials have been focused on men and traditional male activities (*Ibid*, 1997b). When they were represented, women were shown in passive roles (*Ibid*, 1997b). Some middle class girls were able to obtain an education similar to that provided for boys and develop independent careers from the late 19th Century (*Ibid*, 1997b). But mathematical education for upper and lower class children has been differentiated between academic and practical, vocational mathematics (*Ibid*, 1997b). Working class girls were restricted in their education to sewing and sums and in their work prospects to the roles of servant, housewife or factory worker. Institutional racism has also been embedded in schools: in school organisation, assessment, the content of the curriculum, learning materials and behaviour of teachers (*Ibid*, 1997b). This situation in education has only been challenged in the last 30 years (*Ibid*, 1997b).

Harris's (1997b) work is on the interfaces, on the one hand, between the traditionally male activity of mathematics and the traditionally female activities of needlework and, on the other hand, between the tradition of mathematics as abstract and new ideas about making mathematics more meaningful, more connected to real life and other subjects, reflecting the language and culture of people using it.

Although Lave and Wenger (1991) did not investigate formal educational provision, they offered a critique of it, comparing it to apprenticeship systems. They suggested that the sequestering of children in schools denies them full access to adult social worlds, of which they are apprentices. Attention is focused on the students as objects to be changed in educational institutions, instead of on production, as in work situations (*Ibid*). Apprentices change through participating in a practice. The students are also participating in a practice, that of the school or college, but the purpose of the practice is to change the students, in the sense that learning is a change in identity, for example from someone who is ignorant about the curriculum to someone who is knowledgeable (*Ibid*). The relationship between newcomers and experts in the practice is totally different to that in an apprenticeship. In formal educational institutions there are far more students than teachers and students cannot become teachers within the school. Subject experts rarely exist in schools and colleges, only experts in teaching particular subjects: students are not learning physics from physicists but from physics teachers (*Ibid*). Even when expert practitioners in other fields come to teach in educational institutions, they are likely to teach out of date practice, because practice is in a constant state of change and they are no longer in it

(*Ibid*). Or they may select for teaching those parts of practice that lend themselves to this method of instruction (*Ibid*).

In apprenticeship, newcomers learn from observation of more experienced practitioners, from listening and trying to reproduce the discourse of the practice, and from doing parts of the work of the practice (*Ibid*). Verbal instruction is rare (*Ibid*). In education, students learn mainly from verbal instruction, sometimes from demonstration, and from doing their educational work (*Ibid*). Traditionally, verbal instruction is seen as conveying general truth and is therefore supposed to be superior to demonstration, which is seen as conveying narrow and literal truth (*Ibid*). The discourse in educational institutions is different from the discourse of the practice they are learning about: in school they will learn to talk *about* the practice, but when students enter a practice after school or college, they will still have to learn to talk *in* the practice (*Ibid*).

The motivation to learn in schools and colleges is often the 'exchange value' (Lave and Wenger, 1991, p 112) of the certification awarded at the end of the course, which will enable the student to get onto another course or get a job. Learning becomes commoditized (*Ibid*). The use of testing in formal education is parasitic on the learning process (*Ibid*). In formal educational institutions, students have different motivations from teachers and may feel coerced into learning what does not interest them and participating in all the other practices of the schools or college (*Ibid*).

Conflict is described as an integral part of communities of practice in the theory of situated learning (*Ibid*). It arises from the changing patterns of participation and therefore changing power relations between newcomers and old-timers (*Ibid*). There is plenty of conflict in schools, but it does not result in students becoming more central participants. It is more likely to result in them identifying with what Lave and Wenger (1991) call interstitial communities or in more extreme cases, leaving the school, either voluntarily or compulsorily, and losing access to education. What is learnt in educational institutions may not be what the institution intends the students to learn: students learn from each other as much as they do from teachers (*Ibid*).

Socio-cultural theory shifts the focus of attention away from the teacher and the student (or master and apprentice) to the 'structuring resources' for learning in a community of practice: the social relationships, the discourse, the organisation of the practice, and the tools (Lave and Wenger, 1991, p 94). It portrays learning as neither inside the head, nor outside, but in the relations between the individual, the activity and the world.

> ... given a relational understanding of person, world, and activity, participation, at the core of our theory of learning, can be neither fully internalized as knowledge structures nor fully externalized as instrumental artifacts or overarching activity structures. Participation is always based on situated negotiation and renegotiation of meaning in the world. This implies that understanding and experience are in constant interaction - indeed are mutually constitutive. The notion of participation thus dissolves dichotomies between cerebral and embodied activity, between contemplation and involvement, between abstraction and experience: persons, actions, and the world are implicated in all thought, speech, knowing, and learning (Lave and Wenger, 1991, pp 51-52).

The community of practice of teachers within a school is more like a traditional apprenticeship system, where teachers come in as newcomers, work alongside more experienced teachers and eventually achieve mastery at teaching. But teachers do not usually work in the classroom with other teachers: they are sequestered with their students. Nor do they all become (or want to become) headteachers. Heads are given power by another community of practice within the school, the governors.

An education system based on an apprenticeship model would have newcomers and old-timers, both teachers and students, working together, or at least the newcomers would have access to the working practices of the old-timers. The system would have to include, for example, mathematicians 'doing' mathematics, and they would have to make what they were doing visible to less experienced mathematicians. I think this would probably be an impossible situation to set up, because of the power invested in keeping things the way they are.

Brown et al (1989) proposed 'cognitive apprenticeship' (*Ibid,* p 38) as a way of teaching and learning maths, which takes into account the social dimensions (see Section 2.5.3.3). While 'cognitive apprenticeship' (*Ibid,* p 38) sounds like good constructivist teaching, it does not address the fundamental question of how educational institutions are organised. Traditional apprenticeships are organised in such a way that there are similar numbers of 'masters', experienced apprentices and new apprentices. In educational institutions there tends to be a ratio of 30:1 or more of students to teachers and the students are grouped with others of a similar level of experience. In both cases, apprentices or students probably learn more from each other than they do from the master or teacher, but in the case of apprenticeship, there are more experienced apprentices to learn from. A structure for schools that would be more apprentice-like would be if classes were organised 'vertically', i.e. with children of all ages in one class. It would be interesting to see whether maths could be learnt collaboratively up to A-level in such a class.

'Cognitive apprenticeship' (*Ibid,* p 38) does not address the issue of power in learning situations. Lave (1988) describes how this is played out between newcomers and old-timers. Within the classroom, the teacher has all the power and the students do not expect to access any of that power while they are still students. Although students can become teachers, this does not happen within the community of practice of the school: they have to join other communities of practice to qualify as teachers. Educational provision is constructed in such a way that only a proportion of the students succeeds, in terms of gaining accreditation and access to more education and more prestigious work and status in society (McDermott, 1993). This is particularly true of school mathematics, which is used as a gate-keeper to many courses and jobs (Harris, 1997b; Lave, 1988). But the curriculum and accreditation system is constructed in such a way that most students are not expected to progress beyond GCSE level, and even fewer beyond A-level. Students who do not succeed are often pathologised as incapable of learning beyond these points (McDermott, 1993).

2.5.3 Methods of teaching and learning

Others in the field of research into mathematics education have taken up the theory of situated learning and produced various methods of teaching mathematics, which they propose as applications of the theory, for example, Brown's et al (1989) concept of cognitive apprenticeship (see Section 2.5.3.3). It is not always recognised that situated learning is not defined as a method of teaching. The theory proposes that *all* learning is situated, whatever teaching method, or whether none, is being used.

Gal (2000) proposes a set of principles for guiding adult numeracy education: building on learners' existing knowledge and skills; addressing affective factors in learning numeracy;

using practical resources to explore mathematical ideas and providing opportunities for co-operative learning and communication about numeracy; promoting the development of mental calculation, estimation skills and the use of calculators and computers and encouraging the use of multiple solution strategies; using real contexts, including mathematical information in documents and texts to integrate numeracy and literacy learning; and assessing 'a broad range of skills, reasoning processes, and dispositions, using a range of methods.' (Gal, 2000, p 15).

2.5.3.1 Using everyday knowledge in teaching and learning

Nunes, Schliemann, and Carraher (1993) found that learners are more successful when the contexts in which the learning is embedded are meaningful to them. Abstract learning of mathematical procedures may not be well retained and may not be available for application to practical problems.

The traditional way of teaching maths, which can be found in many text books, for example Llewellyn and Greer (1986), presents procedures first and then a series of contextualised problems with the particular procedure embedded in them. It assumes that there is a self-evident hierarchy of mathematical concepts, which students can progress through (Noss, 1990). There is also a tacit assumption that the problems are somehow representative of the real world (outside educational institutions) and the ability to solve them will enable the student to apply the abstract concepts to any field they meet in life (see Section 2.2.3.3).

Adult literacy and numeracy classes use everyday materials, such as local maps, timetables, literature published by local councils, utility bills and newspaper articles and advertisements, as teaching materials. These resources are often copied onto worksheets with questions added, comprehension questions and questions of opinion for literacy work and calculation questions for numeracy, for example, From Wages to Windscale, (Friends Centre, Brighton, 198- [exact year unknown]).

A pack of learning materials, Wrap it up, featuring real problems encountered through research in the packaging industry, was produced for use in secondary schools and for teacher training by Harris (1997b). She also examined the mathematics in needlework from many countries (see Section 2.4.3.4) and developed learning materials, Cabbage, to re-engage the interest of women in learning mathematics and provide new and rich contexts for mathematical instruction.

Schliemann (1999) reports on a range of mathematical knowledge, 'the properties of the decimal system, proportionality, measurement, geometry and probability,' (*Ibid*, p 20) that people learn through their working activities, 'such as buying and selling, carpentry, weaving, lottery, agriculture, tailoring and many others' (*Ibid*, p 20). She emphasises the importance of acknowledging such learning in the development of mathematics education. 'It is by bringing previous knowledge into the process of understanding new situations and representational systems that students develop more advanced mathematical knowledge' (*Ibid*, p 20). She goes on to question how this knowledge can be used.

2.5.3.2 Writing in adult numeracy education

The language experience approach (Schwab and Stone, 1985) has been used in adult numeracy provision, adopting adult literacy teaching methods. In adult literacy work, this involves generating texts in students' discourses by recording students' speech. The texts are then used by the students as material to practice reading, writing, spelling, punctuation and grammar. They can also be published, to validate students' experiences and to provide texts for other students in students' discourses. An extension of this approach is to facilitate students in writing their own accounts of their experiences and publish them. This teaching method, developed in adult literacy work, has been used in adult numeracy classes, for example resulting in the publishing of the Take Away Times (Hackney Adult Education Institute, 1987-90), a series of broadsheets of student writing about their use of mathematics. In Section 7.3, I propose a method of teaching adult numeracy, developed from this approach and using the stories and observations collected in this study.

2.5.3.3 Using a problem-solving approach in teaching and learning

Outside of educational institutions, the solution of problems is part of a larger context of activity (Lave, 1988). In schools, the mathematics problem is an end in itself: these kinds of problems belong to the particular social practice of mathematics education (*Ibid*). Mathematical problems given to students in schools are constructed by other people, rather than being generated from students' activity. There is usually one solution, a precise quantity, deemed correct by the teacher or text book, and it is not negotiable. The method of solving the problem is very often also prescribed by the teacher. The students may have limited control over its solution (*Ibid*).

> Problems of the closed, "truth or consequences" variety are a specialised cultural product, and indeed, a distorted representation of activity in everyday life, in both senses of the term - that is they are neither common nor do they capture a good likeness of the dilemmas addressed in everyday activity (Lave, 1988, p 43).

The Task Process Cycle (Marr and Helm, 2002) was a four-stage model of problem-solving: select relevant information, choose strategy, apply strategy, reflect on outcomes. Gal (1999) had a similar model of the 'management of numerate behaviour' (*Ibid,* p 10): the identification and choice of 'one of several courses of action' (*Ibid,* p 10), followed by 'execute the chosen plan' and 'monitor progress' (*Ibid*, p 10). These models are comparable with the constructivist cycle described by Millroy (1992), after Confrey (1991), which is a similar process, with the narrower focus of solving maths problems in educational settings. In Confrey's constructivist cycle, the first stage was called the 'problematic' (Millroy, 1992, p 26). The problem-solver moves directly from the 'problematic' to 'action' (Millroy, 1992, p 26). Confrey's third stage was 'reflection' (*Ibid*, p 26). Polya (1973) proposed a similar model, where the four stages were 'Understanding the problem', 'Devising the plan', 'Carrying out the plan' and 'Looking back' ('Examine the solution obtained') (*Ibid*, pp xvi and xvii). Each stage had a number of alternative suggestions, making it a complex model. Polya (*Ibid*) and Marr and Helm (2002) recommend that students learn to apply a four-stage of process of problem-solving. Gal's (2000), Confrey's (1991), Polya's (1973) and Marr's (2002) models all embody the underlying idea that problem-solving is a cyclical process: that a first attempt may not be successful and may therefore need to be modified and repeated. I found that the everyday problem-solving in my study was structured in a similar, but more complex way (see Section 5.3.2).

Brown, Collins and Duguid (1989) propose 'cognitive apprenticeship' as a teaching method which is informed by situated cognition theory. It tries 'to enculturate students into authentic practices through activity and social interaction in a way evident - and evidently successful - in craft apprenticeship' (*Ibid,* p 37). This starts with a familiar activity, for example finding the sums of different combinations of coins, which legitimises students' intuitive knowledge of the value of coins and uses it as scaffolding for the next stage. Then students are asked to find different ways of solving a problem and to choose the most appropriate method on the basis of the particular task. An important feature of cognitive apprenticeship is for problems to be 'real': either real mathematical problems, like the construction of a magic square, or realistic in terms of everyday life. Students generate their own solution paths. In doing so they become members of the problem-solving community and acquire the tools they need for this work, like the 'shared vocabulary and means to discuss, reflect on, evaluate and validate community procedures in collaborative process' (*Ibid,* p 38). Teachers' roles are to help students make explicit their existing tacit knowledge, to model strategies for solving problems in authentic activity, to support students' attempts at problem-solving, and finally to empower the students to work independently by 'fading out' their support (*Ibid,* p 38).

Brown et al (1989) emphasise the importance of working collaboratively. This enables social interaction and conversation to 'give rise synergistically to insights and solutions that would not come about without them' (*Ibid,* p 40). Participants are able to play multiple roles in problem-solving activities and to reflect on and discuss their performances. Misconceptions and ineffective strategies, which can remain hidden when students work individually, can be drawn out, confronted and discussed. This method of working also gives students experience of collaborative work practices which are becoming more frequently used in the workplace.

In one example in Brown's (1989) et al study, the students were allowed to construct the contextual problem for the class to solve. I do not think that the problem a student constructed, of twelve jars with four butterflies in each, was any more real than the example of filling a bath with a leaky bucket, which Brown et al (*Ibid*) describe as unrealistic (unless the students had been out catching butterflies for their biology lesson and for some reason unconnected with mathematics, had decided to put four in each jar). I think this example demonstrates that what the teacher really wanted to teach was how to multiply 12 x 4, not how to find the total of twelve lots of four butterflies, and the students knew this and collaborated with the teacher by producing a school maths type of problem.

Brown et al's (1989) other example of cognitive apprenticeship, of a teacher asking students to construct a magic square and then to examine their problem-solving strategies and the mathematics involved, is probably as close as one can get to traditional apprenticeship within the present education system. Even then, the question arises as to whether the teacher is working on the mathematics or working on the students as objects to be changed (Lave, 1988).

Collaborative methods of teaching are less authoritarian than 'chalk and talk' or the interactive question and answer sessions favoured by the British government at present, but they are only less authoritarian teaching methods within an authoritarian educational system. In the examples given by Brown et al (1989), the teacher was choosing the mathematics for the students to work on, presumably within a prescribed curriculum or working towards prescribed examinations.

In the Netherlands, the government requires colleges to give opportunities for students to develop strategic, social and communicative skills as well as maths, language and computer skills. Teachers of adults have developed 'Integrated Mathematical Activities' which are defined as,

> A mathematical activity based upon reality and the historical and cultural background of the student, through which strategic skills, social and communicative skills and mathematical skills are trained and integrated by a student who thereby acquires knowledge and skills to solve his/her daily and professional problems more effectively and more efficiently (Haacke, 2000).

But students can solve their daily problems (Lave, 1988; Nunes et al, 1993). It is school maths that they cannot do.

2.5.3.4. The role of technological tools in learning maths

Gal (2000) describes the use of different technological tools, from audio-recorders and calculators to computers and electronic communication, and argues that the use of technology provides adult learners with opportunities for self-directed and self-paced learning using realistic learning contexts. He also considers the place in the adult literacy and numeracy curriculum of teaching procedures for making informed, valid decisions.

There was a debate in the nursing profession about whether student nurses should be allowed the use of calculators in their studies (Hutton, 1998a). Younger students had used calculators for maths at school, but calculators are not available in all professional nursing situations. Student nurses who had left school within ten years, performed better in mathematical tests with calculators than without (Hutton, 1998a). Older student nurses, aged 27 to 47, did better at straightforward calculation and conversion within the metric system with a calculator than without. But calculators made no difference for them in the word problem part of the test. Both lots of students still made mistakes, with and without using calculators, so Hutton (*Ibid*) concludes that it is important for student nurses to learn to estimate as a check against the use of a calculator. It is also necessary for students to learn to calculate without calculators, to prepare for their professional practice.

2.5.4 The Skills for Life strategy

2.5.4.1 The Moser Report

During the course of my study, in 1999, adults' levels of literacy and numeracy in England were considered by the Working Party under the chairmanship of Sir Claus Moser (DfEE 1999). It concluded from the results of part of the National Child Development Survey (NCDS) (Bynner and Parsons, 1997) (see Section 2.4.4.2) that seven million adults (about 20% of the adult population of England and Wales) lacked the basic skills required in everyday life. The Moser Report (DfEE, 1999) recommended to the government that this deficiency of the adult population should be rectified. The recommendations were enacted as a national strategy for improving the literacy and numeracy skills of adults in England, 'Skills for Life' (DfEE, 2000). This strategy included: a new Adult Basic Skills Strategy Unit (ABSSU) within the Department for Education and Skills; National Standards for Adult Literacy and Numeracy (which correlate with National Standards for other groups of learners); 'context-free' Adult Literacy and Numeracy Core Curricula; new assessment procedures and qualifications for learners; National Standards for teachers; and a National Research and Development Centre for adult basic skills. I consider this strategy in some detail because the dichotomy between school maths and everyday maths, identified by Lave (1988) and Nunes et al (1993) is played out through the instruments of the strategy: the Standards, the Adult Numeracy Core Curriculum, and the National Numeracy Test.

2.5.4.2 The Standards for adult numeracy

The Standards for adult numeracy were to provide a map of the range of skills and capabilities that adults were expected to need in order to function and progress at work and in society.

Numeracy covers the ability to:

- understand and use mathematical information
- calculate and manipulate mathematical information
- interpret results and communicate mathematical information. (BSA, 2001.)

2.5.4.3 The Adult National Core Curriculum

2.5.4.3.1 The epistemology of the curriculum

The Moser Report (DfEE,1999) recommended that the Adult Numeracy Core Curriculum should be 'context free', 'as far as possible.' (p 66.) In writing this, the working party which produced the Moser Report has ignored the findings about everyday cognition published in the last twenty years: that adults are proficient at using maths in their everyday lives, but may find school maths difficult and make no connection between the two kinds of maths. The Moser Working Party also ignored the theory of situated learning: the idea that knowing is active and results from participating in the activities of 'communities of practice' (Lave and Wenger, 1991): the workplace, the family, the college, the numeracy classroom. According to this theory, the actors (the students, the teachers, the bosses, the fellow workers) construct their learning between themselves, other people and the environment. This problematises the idea that knowledge learnt in one situation (the numeracy classroom) can be carried like a set of tools and applied in a different situation (the workplace, the home, the shop), or the other way round.

The result of the Moser Report's concept of context-free maths is a curriculum consisting of lists of arbitrary, unconnected pieces of mathematical knowledge. This is very similar to the school curriculum (DfEE and QCA, 1999), but in a reduced form. There is an underlying assumption that there is a self-evident hierarchy of mathematical concepts through which learners can progress (Noss, 1990), revealing the nostalgic epistemology on which it is based, as is the school curriculum (Brown, 1993).

The language of the curriculum uses the acquisition metaphor of knowledge (Sfard, 1998) (see Section 2.2.1): it treats knowledge as if it had a material existence and can be acquired or built up. 'The skills and knowledge elements in the adult numeracy core curriculum are generic. They are the basic building blocks that everyone needs in order to use numeracy skills effectively in everyday life.' (BSA, 2001, p 8.)

2.5.4.3.2 Contextualisation

Teachers are required to contextualise these basic building blocks, using 'the learner's context' (BSA, 2001, p 8), which they are expected to bring to the classroom. The contexts are also treated as if they are material: they are described as being 'brought' and 'provided' by the learner (*Ibid*, p 8). Having written lists of mathematical packages that are required to be delivered to learners, the authors of the curriculum enjoin providers to make learning numeracy relevant to adults' lives. They give a list of areas where numeracy might be used in everyday life: citizen and community; economic activity, including paid and unpaid work; domestic and everyday life; leisure; education and training; using ICT in social roles. (BSA, 2001, p 3.) The expectation is that learners will 'bring' their 'contexts' (*Ibid*, p 8) from these activities to the learning environment, so that it can be used by the tutor to contextualise the elements of the curriculum.

> ... the learner brings the context which will be the ultimate proving ground for their improved skills. ... What is different is how adults use these skills and the widely differing past experiences that they bring to their learning. This is the *context* that the learner provides (BSA, 2001, p 8).

The authors of the curriculum have tried to reconcile two very different things: the hierarchy of mathematical concepts which forms the curriculum and their list of everyday contexts in which numeracy might be used. The result is a mixture of school mathematics and real contexts, where the school mathematics forms the structure of the curriculum, while the real contexts are there to teach the school mathematics. For example, 'Enter some simple text on a word processor and experiment with different font sizes' (*Ibid,* p 25) is an activity in a real context where numbers are used to indicate relative sizes. But in the curriculum this is given as a sample activity for teaching adults to 'read, write, order and compare numbers up to 100' (*Ibid,* p 24) rather than as an end in itself.

The authors assume that it is unproblematic for students to bring their contexts, that contexts are portable and that students will be willing and able to bring them and they assume that, having learnt an abstract concept through a familiar context, students can then unproblematically apply that concept to other contexts.

> Learners' previous knowledge and experience can be drawn upon to develop new skills and understanding; for example, familiarity with numbers written in decimal notation can form the basis for understanding decimal numbers, which can then be applied in other areas of the curriculum (BSA, 2001, p 7).

Finally the authors assume that what is learnt in the classroom can be unproblematically used outside the classroom. But as in my criticism of the NCDS (Bynner and Parsons, 1997) survey questions (Section 2.4.4.2), I think it is extremely problematic. Because the purpose of the task is to learn elements of the curriculum, the context will only be a pretext. It will be manipulated to represent the required mathematical skill. The practice of education and the practices of everyday life are very different. People calculate very differently in their everyday lives, from the way they do in school situations and are more likely to be successful in their everyday situations (Lave, 1988; Nunes et al, 1993).

The rhetoric of this curriculum is that adults need certain numeracy skills and knowledge to participate fully in this society. But, by basing the adult curriculum on the school maths curriculum and including topics like fractions which are there both for historical reasons and because they are needed further up the school maths curriculum, this curriculum belies the rhetoric of being necessary for everyday life. In the classroom, the learner will know that what is valued in the world of curricula, tests and examinations, is knowing how to do the calculation and to get an exact answer, rather than what they actually do in real life (see Section 2.5.2). They will see the maths they learn as having exchange value, rather than use value (Lave, 1988).

2.5.4.3.3 The content of the curriculum

The curriculum is constructed in five levels: Entry Levels 1, 2 and 3, equivalent to National Curriculum Levels 1-3, followed by Level 1, equivalent to National Curriculum Levels 4 -5, and Level 2, equivalent to National Qualification Framework Level 2 (BSA, 2001, p 4). The trouble with dividing up a curriculum for adults into levels is that everyday life does not present itself in levels. For example, there is nothing on decimals in Entry Levels 1 and 2 of the curriculum; at Entry Level 3 it says, 'Read, write and understand decimals up to two decimal places in practical contexts.' Because the adult curriculum is based on the school curriculum, the different life experiences of adults and children are not taken into account. Adults are using decimal notation for money all the time, but their knowledge has not been recognised. Six year old children (at the equivalent

National Curriculum levels) are not responsible for the finances of their families or the acquisition of food and other necessities and they may not be very aware of written examples of amounts of money. But money is central to adults' lives in a way that it is not to children's. It would therefore be more appropriate for all levels of adult students to be working with written representations of amounts of money over £1, even though these will be in decimal notation and some students will not yet be competent at elements of the curriculum which are deemed to precede decimals, like calculation with whole numbers.

Similarly, for most adults, maps, plans and diagrams will be part of their lives, like the A-Z, bus maps, the weather map on television, floor plans of shops and shopping centres and diagrams of electrical goods. They may not be very confident or competent at using them, but they will be familiar with the basic concept that the map or plan represents the actual landscape or object. But there is nothing on maps, plans and diagrams in Entry Level 1, only 'understand everyday positional vocabulary (e.g. between, inside, or near to)' (BSA, 2001, p 50). At Entry Level 2 there is only 'understand and use positional vocabulary, e.g. on the left, on the right, above, below, behind, etc.' (*Ibid*, p 56), although the sample activities suggest using a simple (local) street plan to practise giving and following directions and describing familiar locations in relation to local landmarks. At Entry Level 3 there is no mention of maps and plans. At Level 1, the curriculum says 'draw 2D shapes in different orientations using grids (e.g. in diagrams or plans)' (*Ibid*, p 66), with the example 'Draw a floor plan to show a room layout.' At Level 2 it says 'recognise and use common 2-D representations of 3-D objects (e.g. in maps and plans)' (*Ibid*, p 72) with some sample activities including extracting measurements from plans and elevations.

There is no mention anywhere of the points of the compass or of using the grid system on maps to locate places. 'Calculate actual measurements from a scale drawing' is a sample activity for 'calculate ratio and direct proportion' at Level 2 (p 43). This is the only mention of using the scales on maps and plans. The curriculum is more focused on teaching the calculation of perimeter and area than on map-reading skills. The authors seem obsessed with tiling, which may be a good way to learn about calculating area, but may be something people only think about once or twice in their lives, unless they do it professionally. This raises the question of whether the purpose is to teach adults about calculating area so that they can tile their bathrooms, as the rhetoric of the curriculum seems to suggest, or to use their knowledge of tiles to teach them about area.

The curriculum states that, 'a learner might be able to understand the concept of area and how it is calculated, but success in solving area problems also requires the ability to multiply numbers efficiently.' (BSA, 2001, p 7.) According to social theories of learning (Lave and Wenger, 1991) people learning to multiply numbers and developing an understanding of area through participating with more experienced others in activities that use this knowledge, like tiling a bathroom. 'What motivates problem-solving in everyday situations appears to be dilemmas that require resolution.' [Lave, 1988, p 139.] However, the curriculum is based on the assumption that it is school mathematics which is used in everyday life and that learning to multiply numbers in a classroom will enable a student to transfer that knowledge to situations outside the classroom.

In the curriculum, in the Common Measures sub-section of the Measures, Shape and Space section, Element 5 says, 'Adults should be taught to calculate with units of measure within the same system.' The example given is to 'Work out the best value of products of different weights or capacities.' Lave (1988) found that in their grocery shopping, adults use a whole range of strategies for comparing the values of different items: by dividing and multiplying; by comparing the difference in weight with the difference in price and deciding whether one was worth the other; by finding two portions with the same weight and comparing their prices; by considering the storage space required for a larger item; by deciding whether they wanted larger or smaller portions; by considering whether they preferred one item over the other. Often participants made several attempts before resolving their dilemmas. They were able to check whether partial or interim solutions were consistent with reality and whether they were likely to reach a satisfactory answer using their chosen method. Then they were able to make more attempts until they were satisfied, or to abandon the problem as not being worth spending more time on. During this process the participant maintained control of the situation: they had generated the problem themselves and they decided how to resolve it. They did not necessarily require a precise answer: an idea of something being larger or smaller was often enough.

But in the curriculum, non-standard calculation strategies are referred to as 'short cuts and tricks' (BSA, 2001, p 43). Students are expected to learn standard written methods of calculation (*Ibid,* p 34). 'There are different written methods of calculation. Teachers need to understand learners' own methods in order to teach standard methods successfully.' (*Ibid,* p 35). I question whether it is necessary for students to learn standard methods if they already know effective non-standard ones. The standard methods will probably only be useful for passing tests and examinations, not actually in their everyday lives.

2.5.4.4 Assessment

The National Numeracy Test (DES, 2005) contains questions, which are school mathematics problems, contextualised as everyday mathematics problems. The contexts are adult situations, for example a slimming club, fishing, and cooking, which will be relevant to some students and not others. The questions have multiple choice answers, only one of which is deemed correct for each question. The questions are open to the same criticisms as the NCDS (Bynner and Parsons, 1997) questions: they test school mathematics knowledge and skill, not whether the candidates can solve real problems in their everyday lives (see Section 2.4.4.2.) The assessment procedures could be structured to measure problem-solving expertise as set out in the Standards (see Section 2.5.4.2), in the contexts listed in curriculum (see Section 2.5.4.3.2). But we should not deceive ourselves that any form of assessment done in an educational situation is going to reveal students' real expertise in their everyday lives.

The Skills for Life Strategy is based on the assumptions that people who do not pass the National Numeracy Test (DES, 2005) are incompetent in their everyday lives and are in need of mathematical instruction. If the DES wanted to test candidates' knowledge of everyday life, they would have to ask questions similar to Johnston et al's (1997) pizza question (see Section 2.4.3.1), or Sewell's (1981) questions in the first part of her study (see Section 2.4.4.1): open questions with an unlimited number of possible answers. Gal (2000) proposes that assessment procedures need to be developed to replace the multiple-choice, computational and standardised testing formats used by providers of adult numeracy education in many countries. This is unlikely to happen because of the difficulty, and therefore expense, of marking answers to open questions (Wragg, 2005).

But there are precedents for such assessment. For example, in the Graded Assessment In Mathematics scheme (Brown, 1992), school students were given open-ended investigations of various kinds of maths: numerical explorations, visual-spatial investigations and everyday problems. Their answers were graded according to ranked responses obtained by systematic research (*Ibid*, 1992).

Another method of assessment was developed within the Realistic Mathematics approach in the Netherlands (van Groenestijn, 2000; 2001): a structure of mathematical topics at different levels was developed as a framework within which 'realistic' mathematical tasks were used flexibly in interaction between the teacher and the learner. Not only were the learners' skills levels assessed, but they were asked to explain their methods of calculation. Van Groenestijn (*Ibid*) claims that training tutors to use this framework resulted in the development of more flexible methods of teaching, using more realistic contexts. However, I do not think that her examples are as realistic as she claims them to be. One example concerns a restaurant owner buying 3000 glasses in boxes of 40 glasses (*Ibid*, 2001). Although these glasses represent real objects, the actual problem, to calculate the number of boxes that the restaurant owner needs to buy, is unlikely to be a problem that many adult numeracy students have actually needed to solve, so that they are unlikely to identify with it. Really what van Groenstijn (*Ibid*) is doing is following the tradition of mathematics teachers: identifying a mathematical process, in this case division of whole numbers, and inventing a problem in an everyday situation, to contextualise it.

Assessing student nurses' mathematical competence is very important. In their professional practice, nurses need to be able to calculate such things as fluid balance, drug dosage and intravenous drip rates, although the amount of such work varies between the four categories of nursing: adults, children, mental health patients and patients with learning disabilities (Hutton, 1998b). In the Common Foundation Programme of nurse education, students performed poorly on a written diagnostic test of relevant maths: basic arithmetic and word problems related to nursing practice (*Ibid*). But when Hutton (*Ibid*) went over the questions with the students in class, she found that they did understand the maths. She compared the students' competence with that of qualified nurses, who do not make mistakes, and found that students only learn the maths when it becomes necessary to use it on clinical placements. She concluded that it would be better to test students' mathematical competence in practical situations, rather than the classroom (*Ibid*).

2.5.4.5 Conclusions about the Skills for Life Strategy

The commitment by the Government to greatly expand numeracy and literacy provision for adults, to widen the range of venues where it can be accessed and to fund more research into adults' needs and how to meet them, was very welcome. There are many adults who have not been able to benefit from the existing education system, for many different reasons. It is important to offer adults opportunities to raise their educational achievement and to make these opportunities as attractive and accessible as possible.

The necessity of having a national numeracy curriculum is questionable. Adults who present themselves for numeracy education have a range of reasons for doing so: helping their children with homework, passing job or course entry tests, having particular everyday problems that they want to solve, or wanting to tackle what they felt they failed at school. Most of them will have had experience of trying to learn mathematics at school and failing. Offering a re-run of the education that failed them in the past does not seem to be appropriate. There are two advantages to having one imposed national curriculum for adult numeracy: the qualification can be easily recognised by employers and other course providers; and it fits in with the National Qualification Framework (Basic Skills Agency, 2001), so that those students who want to progress on to further qualifications can do so without difficulty. The disadvantage of one curriculum is that neither teachers nor students will have any choice over what they teach or learn. The student who wants to help her children with their homework, the student who wants to work out the best source for her electricity, the student who wants to learn mathematics out of general interest and the student who wants to pass a job test are all obliged to follow the same curriculum, even though some of the rhetoric makes it sound as if students have choice. Instead of trying to shoe-horn adult students into the school curriculum, teachers could be helping them to develop their own curriculum.

It is disappointing that the idea of a context-free curriculum was adopted by the government. The motivation for this was presumably to make the Adult Numeracy Core Curriculum fit with other school and vocational curricula and qualifications. However they have made unfounded assumptions about the relationship between school mathematics and the mathematics people use in their everyday lives. By adopting a context-free curriculum they have jeopardised what they purport to be doing: improving adults' proficiency in their everyday lives.

The Adult Numeracy Core Curriculum will empower some learners in the sense that by achieving accreditation they will be enabled to gain access to jobs or further learning. Others will gain personal prestige through gaining accreditation. The mathematics learnt will have 'exchange value' as opposed to 'use value' for the student (Lave and Wenger, 1991, p 112). Others may fail and this will be their second or subsequent failure, undermining their sense of what they are able to do and making them less likely to try again. The experience may not have any effect on the mathematics they use in the rest of their lives, because they may make no connection between 'school mathematics' and what they do in their everyday lives (Lave, 1988; Nunes et al, 1993).

Adults are successful (according to their own satisfaction) at everyday maths (Lave, 1988; Nunes et al, 1993), so they do not need to be improved. What they have difficulties with is school maths (Nunes et al, 1993). Their everyday knowledge and skill could be used to enable them to learn school maths, which they might want or need, for access to work or further education or training, or out of interest. What needs to be improved is school maths, to make it more accessible and more interesting.

In this section, I have discussed literature about maths education and adult numeracy education. This is relevant to my study because of its origins in my involvement in adult numeracy provision, both as a teacher and a teacher trainer. The Skills for Life strategy was developed during the course of my study. Its emphasis on employing the maths that students use in their everyday lives as contexts for learning school maths and its assumption that this will enable the students to solve problems better in their everyday lives, makes it very relevant to my study.

In this chapter, I have discussed literature that has relevance to my study, both literature that informed the methodology and design of the investigation, and influenced my research questions, and literature that informed me during the analysis and writing up of the study. This literature ranged over the fields of theories of learning, the relationship between emotion and cognition, and everyday cognition. Although the study is about everyday problem-solving, rather than maths education, my background as an adult numeracy teacher made me realise the implications of my findings for adult numeracy education, and I have therefore included some literature in this field. In the next section, I formulate my research questions for the study.

2.6 My research questions

I formulated tentative research questions at the beginning of the study:

1. What mathematics, in particular spatial relationships, do adults use in their everyday lives?
2. What sorts of processes do adults use to solve maths problems?
3. How do situations affect these problems and their solutions in everyday life?
4. What are the personal resources that adults bring to constructing and solving problems in everyday life?
5. Do individuals have different modes of thinking and do these influence the ways in which they perceive, construct and address problems in their everyday lives?

Because this was an exploratory study, I found that my questions developed and changed during the course of the investigation. They were influenced by my ongoing findings, by the analysis of the data, by the process of writing about the data, and by literature that I read during the study. My final version of the research questions is as follows:

1. How do the socio-cultural contexts of a wide range of activities and occupations impact on everyday quantitative and spatial problems and their solutions?
2. How are problems and their solutions structured?
3. How does the agency of individuals interact with the socio-cultural contexts in the problem-solving process?

Trying to define what is and is not maths is a notorious minefield (von Glasersfeld, 1983; Ernest, 1994; Evans, 2000). So although I set out on the study with research questions formulated in terms of mathematics, I have decided to avoid rehearsing this discussion by re-formulating my research questions in terms of solving problems. I have therefore used the phrase ‘quantitative and spatial problems and solutions’ to indicate that the focus of this study is on 'problems' and 'solutions' which have a quantitative or spatial aspect to them, but which are structured in non-mathematical activities. But the use of the words 'problems' and 'solutions' is also problematic. Not all of the events and stories in the study represent problems and solutions in the everyday sense of these words: many of them are routine practices that the participants perform. Sometimes the 'solution' to a 'problem' is to decide not to solve it in a mathematical sense. I am therefore using 'problems' and 'solutions' as analytical tools, rather than in their everyday sense.

In the next chapter, I discuss the methodology of the study.

Chapter 3. The methodology and design of the study

3.1 Introduction

In this chapter, I discuss my aims in doing this study, my theoretical stance and my chosen methods. I describe how I designed the study and why, and how I set about doing it, how I selected the participants and why, who they were, and the methods I used to collect and analyse my data and why I chose them.

3.2 The aims of the study

My starting point for doing this research was as a teacher and teacher educator who wanted to understand better how adult students construct and resolve quantitative and spatial problems in their everyday lives. Other researchers have studied mathematics in work: carpenters, builders, market traders, fishermen, farmers (Nunes et al, 1993); carpet-layers (Masingila, 1992); child candy-sellers (Saxe, 1991); midwives, tailors, butchers, quartermasters on ships (Lave and Wenger, 1991); carpenters (Millroy, 1992); fashion and packaging industry workers (Harris, 1997b); nurses, airline pilots and bankers (Hutton, 1998a, 1998b, 1998c,; Hoyles, Noss and Pozzi, 1999), and insurance clerks (Wenger, 1998). I wanted to do an exploratory study of occupations that had not been studied before, to see what quantitative and spatial problem-solving was involved in their pursuit, to add to the knowledge we have of mathematics in work. Lave (1988) studied quantitative problem-solving in activities outside working situations: grocery shoppers, members of Weightwatchers preparing their meals, families' organisation of their finances. I wanted to explore further quantitative and spatial problem-solving outside working situations to increase our knowledge of how mathematics is used in these circumstances.

Harris (1997b) found that employers tend to ignore spatial relationships, when listing the maths their workers use, but that many areas of work require an understanding of it. Many of the above studies involve spatial relationships, but in many studies of adults' use of maths in their everyday lives in this country (Sewell, 1981; OECD, 1997), spatial relationships are only given a minimum amount of attention. I therefore aimed to make them a main focus of my study. I was also interested in studying women's use of maths, as an area which tends to have too little recognition (Harris, 1997a).

My aims in doing this study were therefore, first, to contribute to the theory of everyday cognition by gaining fresh insights into adults' use of maths in their everyday lives. My research questions were therefore formulated as follows, as I stated in Section 2.5.

1. How do the socio-cultural contexts of a wide range of activities and occupations impact on everyday quantitative and spatial problems and their solutions?
2. How are problems and their solutions structured?
3. How does the agency of individuals interact with the socio-cultural contexts?

Second, I wanted to enable the voices of ordinary people, many of whom are not confident about their mathematical abilities, to be heard with respect to their proficiency in constructing and resolving quantitative and spatial problems in their everyday lives. Through the investigation of a wider range of occupations and activities than have been studied before, I wanted to make the data I collected available to adult numeracy teachers and learners, so that my participants' knowledge and experiences could be used to facilitate adult learners and their teachers in recognising their own knowledge and expertise, so that they can use these in the development of further maths understanding. I hope that the results of this study will empower the participants, and others, to understand and change their worlds, particularly their attitudes to maths and their own and others' 'abilities' to use it.

In this section, I have described my aims for the study. In the next section, I discuss my theoretical stance.

3.3 My theoretical stance

As a teacher and teacher educator, the theory underlying my practice was constructivist (Skemp, 1971). Constructivism focuses on the individual learner, who is seen as solely responsible for the construction of her or his own knowledge (Goodchild, 2005). Knowledge is seen as being organised into structures and schemas in the mind and new experience is both interpreted in terms of these schemas, through reflection, and influences the modification of the schemas to accommodate it. Social aspects of learning are considered as less important.

On commencing this study, I read the theory of situated learning (Lave, 1988, Lave and Wenger, 1991) and found it so revelatory, not only of everyday practice, but of learning, that I wanted to use it as the framework of my research: to investigate people's everyday practices embedded in their social and cultural contexts, which cannot be ignored. So the over-arching theory that has influenced the design of this study is the theory of situated learning (Lave, 1988; Lave and Wenger, 1991: Wenger, 1998). This theory positions human experience as embedded in social and cultural contexts. Behaviour cannot be understood without its environment: this must be explored and understood. Later, when I was analysing my data, I found Saxe's (1991) model of culture and cognitive development useful because it focuses on the different cultural parameters involved in problem-solving: activity structures, social interactions, artifacts and conventions, and prior understandings. Saxe's model does not work in opposition to Lave's and Lave and Wenger's theory. I see it more as being contained within it, except that the parameter 'prior understandings' seems to belong more to cognitive theories than socio-cultural ones. It does, however, address one of the issues that Lave and Wenger's theory problematises: whether knowledge learnt in one situation can be transferred to another situation. Some of the data in my study was not fully explained by socio-cultural theory: different people had very different trajectories through communities of practice, which the theory does not seem to take into account. I found Tomlinson's (1998) matrix useful for distinguishing different ways of knowing. (See Section 2.2 for a fuller discussion of these theories of learning.)

In this section, I have discussed my theoretical stance. In the next section, I discuss the suitability of different methodologies for my study, focussing on phenomenology and ethnomethodology as being the two that I chose for the study.

3.4 Methodologies

I needed to find methodologies concerned with everyday knowledge and which value information gained by direct observation of participants' everyday activities on the one hand and participants' own accounts of their experiences on the other hand. There has been debate for the last century about the best way of studying culture (Atkinson and Hammersley, 1994). Some researchers have favoured following the empiricist methods of the study of the physical sciences, which seek universal laws. For more than 100 years, social research was dominated by scientific research methods, with their emphasis on objectivity, neutrality, measurement and validity (Campbell, 2005). Other methods were criticised as being too open to multiple interpretations, too biased, too subjective, not scientific and not rigorous. In the last 40 years, the dominance of the scientific method has been challenged, on the bases that although the scientific community supposes that scientific knowledge is free from social construction, in fact it is founded on tacit beliefs, principles and assumptions, that the 'objectivity' of science is often sexist and therefore not objective, that objectivity imposes hierarchical relationships between the researcher and the researched, that there are research questions which it cannot answer, and that 'objectivity' excludes subjective knowledge, which therefore goes unexamined (Burton, 2005; Campbell, 2005). Alternative research methods have been developed, based on hermeneutics, the study of how history can be understood. Social science began to be seen as distinct from physical science,

> because in seeking to understand human actions and institutions we could draw on our own experience and cultural knowledge, and through that reach understanding based on what we share with other human beings, despite cultural differences (Atkinson and Hammersley, 1994, p 250).

There is now a developing consensus that there is a diversity of ideas about how human social life can be understood and that both quantitative and qualitative research methodologies are useful, for different situations (Atkinson and Hammersley, 1994) and that none of them is perfect.

> There is, then, no position or method that you can adopt which will give you an indisputably clear view of the empirical field ... which you want to investigate and about which you want to make statements. (Brown and Dowling, 1998, p 8.)

For my purposes, qualitative methodologies were appropriate, because I wanted to do an exploratory study and collect unstructured observations of participants' activities and participants' perceptions of their experiences, in their own words. I now discuss two qualitative methodologies, phenomenology and ethnomethodology, both of which I chose to use for different parts of the study.

3.4.1 Phenomenology

Phenomenology is concerned with direct experience and using our subjective consciousness, which is active in bestowing meaning, through reflection (Brewer, 2003). Husserl, the founder of transcendental phenomenology, investigated the sources of the foundation of science and the commonsense, taken-for-granted assumptions of everyday life. He was concerned with how things appear directly to us through our senses. He looked for the essences of our experiences beyond the minutiae of everyday life and our cultural and symbolic structures that overlay them. Husserl claimed to do this by putting the world in brackets, so freeing himself of his usual perceptions of the world, and using his consciousness to examine the underlying reality (Stanage, 1987). This consciousness contains three elements: the person thinking, the 'I', the thoughts of the person, and the objects being thought about. The central and defining problem of phenomenology, and of maths education, formulated by Husserl, is to reconcile the objective validity of logic and maths with the inherent subjectivity of lived experience (Campbell and Fiske, 1959).

Schutz developed existential phenomenology by applying Husserl's theory to the study of social behaviour and the meanings of everyday life (Coulon, 1995). His method for doing this was to reflect back on experiences to identify their meanings in relation to the goals the person was seeking. Schulz suggests that we all make sense of the myriad phenomenon in our worlds by constructing typifications of events, people and things, within the social contexts in which we live (Gubrium and Holstein, 2000). These typifications vary from one situation to another: we apply them to new experiences in order to understand them and make them familiar. People inhabit many different situations and are adept at moving from one to another, changing their consciousness as they do so. Phenomenology therefore relates well to Lave and Wenger's (1991) theory, that learning is socially situated. Phenomenological research is,

> the ascertaining of the presence or absence of certain phenomena or certain properties, characteristics, marks or attributes, in order to bring to light, to discover, to un-conceal, whatever might be present, to locate, to test, to reveal, to penetrate more deeply into the everydayness of the familiar lifeworlds of persons. (Stanage, 1987, p 279.)

Phenomenological research is therefore a venture into the field without knowing what will be discovered. Having found phenomena in the field, the researcher tries to ascertain the essences of these phenomena by reflecting on what she has uncovered (Stanage, 1987). The phenomena under investigation are the participants' perceptions of their worlds.

> A researcher must first take into account the points of view of the actors under study, because it is through the meaning that they assign, to objects, to people, and to the symbols that surround them that the actors build up their social world (Coulon, 1995).

It seemed to me that a way of achieving my aims would be to take a phenomenological perspective, to try to put myself in other people's shoes, 'to see what the world looks like from there' (Arthur, 1995, p 446), to try to achieve empathy with other people in their experiences of using maths in their everyday lives, experiencing 'an imaginative participation in the world of the actor' (Arthur, 1995, p 453). I wanted to collect information from people about their own perceptions of their experiences of using maths and number in their everyday lives because, as a teacher, I believe that teaching cannot be done effectively unless we understand the experiences of our students outside the classroom and the experts in those experiences are the students themselves. I therefore decided to set up an Everyday Maths Group, to which I would invite people who were willing to recount their experiences of constructing and resolving quantitative and spatial problems in their everyday lives. I hoped, as a result, to be able to put myself in their shoes and understand their perceptions of quantitative and spatial problem-solving.

3.4.2 Ethnomethodology

Ethnomethodology was developed from phenomenology by Garfinkel (1968). It focuses on practical social reasoning: how people's everyday activities are realised, and, especially, how they understand the world and how they communicate their understanding to others (French, 2005). Ethnomethodology aims to describe how social concepts can be realised and made visible. It aims to describe how ordinary people construct knowledge and understanding and to specify the implicit rules that constitute shared bodies of knowledge. Ethnomethodology focuses on the process of the construction of knowledge: how knowledge is made legitimate and verified. It is used to discover the taken-for-granted knowledge that members of a group hold to operate in a specific situation. Garfinkel defined ethnomethodology as a study of members' (participants') ordinary linguistic and interactional skills and their methods for producing the accountable features of everyday life (Gubrium and Holstein, 2000). Ethnomethodology,

> sets out to treat practical activities, practical circumstances, and practical sociological reasonings as topics of empirical study, and by paying to the most commonplace activities of daily life the attention usually accorded extraordinary events, seeks to learn about them as phenomena in their own right (Garfinkel, 1968).

Garfinkel challenged the basic sociological concepts of social order. He advocated that investigators of the social world should doubt the reality of that world. He saw social reality as constantly created and recreated by members of the social world (Acton, 2003).

He proposed the concept of indexicality: that actions and statements are not always stated explicitly, because meanings are shared between participants and are understood in relation to the social contexts in which they occur. He also created the concept of reflexivity: that all accounts of social situations, descriptions, analyses and criticisms, are mutually interdependent with the social situations. Indexicality relates well to Lave and Wenger's (1991) theory of situated learning, which sees all learning as socially created. Garfinkel's aim was to uncover the taken-for-granted everyday practices through which people construct reality and make sense of their own and others' activities and make them a matter of theoretical interest (Acton, 2003).

As a sociologist, Garfinkel's focus was the social order constructed between members. In particular, Garfinkel was interested in how members 'orient and use rules, norms and shared meanings to account for the regularity of their actions', 'their substantially adequate ways of interpersonally orienting to and interpreting the world at hand' (Gubrium and Holstein, 2000, p 491). Ethnomethodologists investigate ways in which people negotiate the social situations in which they find themselves and how people make sense of and order their environments. More recently, Coulon (1995) defined the 'scientific project of ethnomethodology' as 'to analyze the methods, or the procedures, that people use for conducting the different affairs that they accomplish in their daily lives.'

I therefore considered that ethnomethodology would be a suitable methodology for me to investigate adults' construction and resolution of quantitative and spatial problems in their everyday lives. I decided to look for working situations which had not been studied before, where the workers were likely to be involved in the construction and resolution of quantitative and spatial problems and where I could directly observe their activities and have conversations with them about their work. I found a gardening firm and a professional upholsterer who also taught upholstery to adults in a community workshop. The mathematical thinking that adults use in problem-solving in their everyday lives is the taken-for-granted knowledge that I wished to uncover by observation and by talking to the participants. My focus was mathematics within the social order of the gardening firm and the upholstery workshops. So as well as the social interactions of the gardeners and upholsterers, I needed to consider the concrete worlds of furniture and upholstery tools and materials, and plants, soil, weather, and gardening tools and materials. The participants' concepts of these things depend on their physical properties, like strength and stretchability of materials, as well as the socially constructed ways of using them, the knowledge, manual skills and methods used in the practices of gardening and upholstery. Without these there would be no cultivated gardens or upholstered chairs. Gardening and upholstery would be the basic subject matter of the linguistic and interactional interchanges between the participants and between them and me, but I also planned to observe them doing the practical tasks of gardening and upholstery.

In this section, I have discussed the phenomenological and ethnomethodological methodologies that informed my investigation of the maths adults use in their everyday lives. In the next section, I describe the situations in which I gathered data, recount who were the participants in the study and how I recruited them and discuss the methods I used to gather data. I also explain the methods I used to analyse the data.

3.5 The design of the study

My Research Questions (see Section 2.5) frame the empirical part of the study. I planned the study in three parts. In the first two parts of the study, I took an ethnomethodological stance in investigating professional and student upholsterers and professional gardeners at work. First, I observed an upholstery class of adults and a professional upholsterer in his workshop. Second, I observed a small firm of gardeners at work. In the third part of the study, I used a phenomenological approach, in setting up a discussion group of women, the Everyday Maths Group, which focussed on how the participants used maths and number in their everyday lives. I asked them to describe situations in their everyday lives, where they had used maths or numbers in some way.

To carry out their research, ethnomethodologists and phenomenologists both use ethnographic methods, like observation and interviewing. I set out to explore the nature of adults' construction and resolution of problems in their everyday lives. Although I had read others' accounts of their investigations in this field (Lave, 1988; Saxe, 1991; Nunes et al, 1993) and in the larger field of how adults learn in their everyday lives (Lave and Wenger, 1991), I did not set out to test hypotheses formulated from their work. Lave and

Wenger's (*Ibid*) theory of situated learning informed the way I decided to collect my data. I did not plan to collect data narrowly focussed on calculation as Nunes et al did, but to investigate the socio-cultural contexts of problem-solving as holistically as possible. I aimed to work with unstructured data, investigate a small number of cases and analyse my data by interpreting the meanings and functions of human action, producing verbal descriptions and explanations. My account of the gardeners' and upholsterers' practices follows the tradition of other ethnomethodological accounts: it describes the everyday working lives of the participants and includes extracts from conversations between the workers, between the workers and their customers, and between the workers and me. My account of the practices of the participants in the Everyday Maths Group is phenomenological: it presents 'the everydayness of the familiar lifeworlds' (Stanage, 1987, p279) of the participants from their point of view.

The observations of people at work and the discussions in the Everyday Maths Group were intended to complement each other. In the working situations, at the upholstery workshops and in the gardens, I directly observed the construction and resolution of problems. In the Everyday Maths Group the participants told me about events in their everyday lives: they gave me *post hoc* accounts of their construction and resolution of problems. So these different parts of the study made a form of methodological triangulation (Campbell and Fiske, 1959), although there were different participants in each part of the study. I now consider the design of each part of the study in turn and critique my methods.

3.5.1 The upholstery workshops

In this section, I describe my ethnomethodological investigation of professional and student upholsterers and discuss who they were, why I chose to study them, how I did it and why, how I analysed the data and I discuss some of the problems that I encountered. I decided to study upholstery for three reasons. First, it was convenient: I came across Sean, the upholsterer, by chance, through personal contact. Second, he seemed to be willing to take part in the study. Third, I thought that upholstery would be an interesting craft to study, because it would require the use of spatial relationships, which is a neglected area of everyday cognition in this country (Harris, 1991).

3.5.1.1 The upholsterers

Sean was a professional upholsterer: he had his own small shop-cum-workshop in London, where he undertook the repair, re-upholstery and re-caning of chairs, settees and stools for customers. He also rented out bench-space to other upholsterers, to some of whom he gave some help and advice. In addition, he taught upholstery to two classes a week at his professional workshop and one day a week at a local community workshop scheme. The purpose of this community scheme was to enable adults to learn craft skills in upholstery, joinery, pottery and printing, up to a professional standard, as preparation for work. As well as classes, the scheme provided workshop time, with technical help, but without tuition, so that the members could continue to work on their projects outside class time. In the upholstery classes, students brought their own pieces of furniture, which they stripped down, repaired, re-finished, and re-upholstered or re-caned over a number of weeks, with individual instruction and assistance from Sean. The scheme provided tools and storage space.

As Sean was teaching at the community workshops, he invited me to visit his class. My intention had been to observe him in his professional workshop, rather than in his teaching capacity. I had not originally intended to gather data in educational establishments, because I wanted to know how people used maths in everyday life, not in education. But as this was an upholstery class, not a maths class, I decided to accept Sean's invitation to observe his class and ask to visit his professional workshop later. Because the focus was upholstery, not maths, I consider the upholstery class to be 'outside' maths education.

3.5.1.2 Data collection

In the first part of this study I decided to follow Lave's (1988) methodology by observing and conversing with people while they were involved in activities, taking note of the whole activity and situation, not just any calculations. She used an iterative methodology, which reflects her theory of how dilemmas are resolved in everyday life, combining observation of real practice with interviews and experiments. My intention was to try to identify subsequently any quantitative and spatial problem-solving in the activities. By this method I expected to gather the social contexts of problem-solving, as well as the construction and resolution of problems.

The distinction between participant and non-participant observation is not clearly defined.

> In a sense all social research is a form of participant observation, because we cannot study the social world without being part of it. From this point of view participant observation is not a particular research technique but a mode of being-in-the-world characteristic of researchers (Atkinson and Hammersley, 1994, p 249).

There are several dimensions of variation in participation and observation.

> Whether the researcher is known to be a researcher by all those being studied, or only by some, or by none
>
> How much, and what is known about the research and by whom
>
> What sorts of activities are and are not engaged in by the researcher in the field and how this locates her or him in relation to the various conceptions of category and group membership used by participants
>
> What the orientation of the researcher is; how completely he or she consciously adopts the orientation of insider or outsider (Atkinson and Hammersley, 1994, p 249).

Sean knew I was primarily interested in the maths they were using, but the students were told that I was studying adult education. We decided to do this because we thought the students might be frightened by the idea of maths, as Buxton (1981) describes, and become unable to talk freely to me. I also thought that the students might deny using any maths, as Harris reported.

The question of what kind of an observer I was going to be was not one that I felt that I could answer, before going into the field. I did not intend to 'become' an upholsterer, in the way that Millroy (1992) became a carpenter, because I did not have the resources to spend so long in the field. I was not trying to understand how to be an upholsterer, but in the quantitative and spatial problem-solving that upholsterers do. But I wanted to get as close to the upholstery as I could, without actually participating, so that I could observe different people doing different tasks in one session. If I had been a fully participating observer, I would have spent a lot of time banging tacks into furniture, without necessarily being able to see what the other participants were doing. I felt that I could only work out what I was going to do and how I was going to do it, once I was in the situation. The way it worked out was that, in the sense that I did not do any upholstery, I was not a participant. But in the sense that I was present and conversing with the upholsterers, I was someone who was participating, although differently, in the community of practice. I would describe myself as a peripheral participant observer: I participated in a peripheral fashion, but my main focus was observation. Because I was peripheral, I did not feel threatened by the possibility of 'going native' (Gold, 1958, p 221). I was more vulnerable to collecting what Gold describes as 'inadequately understood universes of discourse'.

I visited Sean's workshop class at the local project twice, watched Sean and the students at work, and asked them questions about what they were doing. The students explained to me what upholstery processes they were using, what they had previously done, and what they intended to do next. I also visited Sean once in his professional workshop, watched him working, and asked him to explain what he was doing. Table 4.1 lists my visits to the upholsterers.

3.5.1.3 Recording the data

I did not take field notes during my visits to the upholsterers, because I thought they might find this off-putting and it might discourage them from talking to me freely. I did draw some diagrams because I thought I would find it more difficult to remember spatial configurations than conversations. I think drawing was probably less threatening to the people I was observing than taking notes, since they could easily see what I was drawing. Immediately after each visit I wrote down everything I could remember about what I had seen and heard, and drew more diagrams and plans. At this stage I did not attempt to distinguish between mathematical and non-mathematical data.

Garfinkel suggests that researchers should take a standpoint of 'ethnomethodological indifference', to suspend their own view of the reality of the social world, in order to collect examples of the members' practical reasoning (Gubrium and Holstein, 2000 p 490). But I do not believe that it is possible to do this completely. I tried to be as open-minded as I could towards what I was seeing and hearing, and to be aware of my own preconceptions and judgements. But as Brown and Dowling (1998) have said, my views of the world and beliefs are part of my cultural background and experiences and I am not necessarily aware of all of them.

I tried to be aware of my beliefs about what I would find. The subject matter of my study was both very familiar and alien to me. Just like any other adult in late 20th Century Britain, I encounter many quantitative and spatial problems in the course of my everyday life. I do my best to resolve them, sometimes with difficulty, but because I see myself as being 'good at maths', I approach them with confidence. However, I know that my attitudes to and feelings about maths are very much a minority view: most people have had a different experience to myself of learning mathematics at school. They do not have positive attitudes and feelings towards 'school maths' (Galbraith and Chant, 1990) and they probably do not recognise the quantitative and spatial problem-solving that they do in everyday life, as mathematical (Harris, 1991). Therefore I expected the participants in the study to have a different perception of maths in everyday life to my own.

Through my experience of teaching maths to adults, I expected the participants to be competent at constructing and resolving problems in situations that were familiar to them, by using sets of familiar procedures, rather than understanding the underlying mathematics. From my experience of trying to teach students to solve school maths problems, I did not expect the participants to be necessarily competent at constructing logical problems and solutions. Like Luria (1979), I saw that as the province of those who, like myself, had experienced a successful mathematical education, which I knew was not the case with the majority of the population.

3.5.1.5 Analysing the data

I systematically coded the fieldnotes of the visits to the upholsterers, using Lincoln and Guba's (1985) method for developing grounded theory. I labelled words, phrases and sentences with codes that described the content. I then made a list of the codes and organised them into a schema. Examples of the codes are: 'following procedures', 'knowledge of materials', 'identifying a problem'. In choosing these names for pieces of text, I was influenced by what my interests in the data were: first, the nature of the quantitative and spatial problems that adults construct in their everyday lives; second, how the problems are constructed and resolved; and third, what constitute satisfactory resolutions to these problems to the participants. But I also found data I had not anticipated: for example emotion was prevalent throughout the data and needed codes to identify it.

I have described and discussed my observations of a professional upholsterer and his students in a community workshop. I now turn to the part of my inquiry where I observed gardeners at work.

3.5.2 The gardening firm

When I was looking for situations where I could observe people at work, I discussed this with my son, who is a professional gardener. He suggested that Joe, for whom he used to work, might be willing for me to observe his firm. I knew Joe slightly from the time when my son worked for him, so I rang him and he agreed to see me at work. On my first visit, Joe talked a lot about his work and said that he would be interested in my analysis of it. He wanted to expand the business, but was having difficulty in finding, training and retaining good workers.

3.5.2.1 The gardeners

Joe had a small gardening business, Metamorphoses, which offered restructuring and maintenance of gardens to corporate and private customers. His business card offered any work to do with gardens. Metamorphoses put up fences and trellises, constructed decks and patios, installed automatic watering systems, laid lawns and planted and cultivated flower beds.

Joe had several people working with him. Ben and Gerry were two young men in their late teens, who had been working for Joe for about six months at the time of the study. They had mainly learnt to put up fences and construct decks. Freddie was a man in his forties who had been working for Joe for a few weeks. He told me he had been a rock star in the 70s. His previous experience of gardening was from having his own allotment. Halfway through the study, Joe sacked him for incompetence. Lee was a student who had previously worked full-time for Joe and had about ten years' experience of gardening work. He had arranged with Joe to do some weeks' work whenever his Student Loan ran out and during the college vacations. He came to do some work half way through my study, after Joe had sacked Freddie. Mick was a builder to whom Joe had sub-contracted the building of two patios at one of the gardens I visited. He had finished by the time I came to visit the garden so I did not meet him, but I heard a lot about him.

3.5.2.2 Data collection

As with the upholsterers (Section 3.5.1.2), I wanted to follow broadly the method of investigation that Lave (1988) used in her study of grocery shopping, with the gardeners in my study, without having a fully structured plan of how I would behave in the situation. I observed and conversed with the gardeners, while they worked, taking note of the whole activity and situation, not just any calculations that they were performing. I did not participate actively in the gardening process, so that I could observe different people doing different tasks in one session. Besides not having the physical strength to work as a professional gardener, I might have spent a lot of time laying turf, without necessarily being able to see what the other participants were doing.

Professional gardening is rather unpredictable in terms of time: it is dependent on the vagaries of the weather and deliveries of materials. Although Joe concentrates mainly on one garden at a time, he does fit small jobs, his maintenance contracts and his estimate visits into his schedule, as well as trips to nurseries, garden centres and builders merchants, to buy plants and materials. Sometimes deliveries of materials are late and it is necessary to deploy the workers elsewhere. We decided, therefore, that I would arrange each visit at the previous visit and Joe would ring me if he found that he was going to be somewhere else.

I visited the gardeners several times while they worked on three gardens, watching them work, asking them questions about what they were doing, how and why, and listening to their conversations with each other. I took the role of a peripheral participant observer, as I had with the upholsterers (Section 3.5.1.2). I also accompanied Joe twice when he visited potential customers to do estimates for them. Table 4.2 lists my visits to the gardeners.

3.5.2.3 Recording the data

As with the upholsterers, I did not take field notes during my visits to the gardeners, because I thought they might find this off-putting and it might discourage them from talking to me freely. Immediately after each visit I wrote down everything I could remember about what I had seen and heard, and drew diagrams and plans. At this stage I did not attempt to distinguish between mathematical and non-mathematical data. However, I am aware that memory is selective. I probably only wrote down what was meaningful to me and there were probably many things that I did not notice, or did not remember. 'The presence, the effect, the biases and selections of the researcher cannot be removed from qualitative research.' (Ball, 1990, p 167.) Garfinkel suggests that, in order to collect examples of the members' practical reasoning, the researcher should suspend her or his own view of the reality of the social world, to take a standpoint of 'ethnomethodological indifference', (Gubrium and Holstein, 2000, p 490). But it is not possible to do this completely (Brown and Dowling, 1998). As I discussed in Section 3.5.1.3, I tried to be aware of my own preconceptions and judgements about what I was seeing and hearing and as be open-minded as I could, but I am not necessarily aware of all my beliefs and views of the world, which are part of my cultural background and experiences.

3.5.2.4 Analysing the data

As with the upholstery fieldnotes (Section 3.5.1.5), I systematically coded the fieldnotes of the visits to the gardeners using Lincoln and Guba's (1985) method for developing grounded theory. I labelled words, phrases and sentences with codes that described the content. Examples of the codes are: 'estimation', 'planning the resolution of a problem'. My choice of these labels for pieces of text was informed by my interests in the data: how the socio-cultural contexts of activities influence the construction and resolution of quantitative and spatial problems in everyday life, the structure of the problems are and their solutions, what constitute satisfactory resolutions to these problems to the participants and how the agency of the problem-solver interacts with the socio-cultural contexts. But there were also unexpected data: for example there were different expressions of identities in the data, which needed codes to identify them.

In Sections 3.5.1 and 3.5.2, I have been describing and discussing my observations of upholsterers and gardeners. I now turn to the third part of the study, the Everyday Maths Group that I set up, where I invited the participants to describe their use of maths and numbers in everyday life.

3.5.3 The Everyday Maths Group

As a complement to the study of people at work, I wanted to investigate how adults use maths in their activities outside of working situations. I considered doing my investigation in adult numeracy classes, as a convenient way of reaching participants who were not confident about doing school maths. However, I was concerned that students' responses to inquiries about the maths they used in their everyday lives, made whilst they were situated in a maths education environment, might be coloured by their activities inside the classroom, or by perceptions of me as a maths teacher. I therefore decided not to use adult numeracy students as participants.

I had to think of a way of finding participants for the study outside of educational establishments and work situations. It was difficult to think of another existing group of adults who might be willing to take part in the study, given that mathematics is a subject about which many people suffer acute anxiety (Buxton, 1981). I could have conducted individual interviews, but I felt that there were two advantages to bringing the participants together in a group. First, as Sewell (1981) did (see Section 2.3), I expected to have a great deal of difficulty in recruiting participants, because of many people's fear of mathematics (Buxton, 1981). In asking people to come to a group and offering them lunch afterwards, I thought they might feel more supported and less focused on and they would feel that they could sit quietly if they wished. But, second, I thought that in hearing each other's responses, the participants might be stimulated to contribute to the discussion. As a teacher of adults I have often conducted discussions amongst students, where they were encouraged to contribute accounts of their experiences. So this seemed to be a familiar way to work.

I also wanted to assess the effectiveness of collecting data by this method, following a personal conversation with Betty Johnston, when she told me about the group she had set up for research into the role mathematics plays in women's lives (Johnston, 2002), which made me feel that it would be useful to study a group of women. Harris (1997a) has shown that the maths women use in their work and leisure activities tends to go unrecognised in British society.

I decided to hold the group in my own home, to avoid triggering memories of school maths, as might have happened if we had met in an educational institution. I hoped that, in my own home, I would be seen primarily as a woman, rather than a maths teacher. I also thought people would find a home setting more reassuring than any kind of institutional setting. By creating an ambience of women having coffee and lunch together, I hoped that the participants would not think about their experiences of learning maths in school and their relationships with their teachers, but think and talk about other areas of their lives. I called the group the Everyday Maths Group.

3.5.3.1 The participants

I decided to use Sewell's (1981) method of gathering participants for the group: using my personal network of contacts. I invited women I knew, through work and social contacts, and their friends to come to the group. I was not at all sure that I would be able to recruit participants in this way: Sewell had had a 50% refusal rate for her study. I tried to make the group as unthreatening as possible to the people I invited to join. I had discussed my interest beforehand quite extensively with each of the participants individually. I promised them that they would not be asked to do any maths, but only to talk about their experiences. The weakness of finding participants in this opportunistic way is that it cannot be said to be representative of any larger population.

Although most of the participants in the group knew me, they were not necessarily acquainted with each other, so they did not constitute an existing community of practice, as a group recruited through another organisation or institution would have done. I thought it was very unlikely that the people in the group would have talked to each other before about the maths they use in everyday life. The stories they told were therefore more likely to be fresh, rather than rehearsed.

3.5.3.4 Data collection

The data I wanted to collect were the participants' accounts of the meanings they had constructed about their experiences, mediated by their 'prior knowledge, constructs, categories, folk theories, beliefs, values and attitudes' (Gubrium and Holstein, 2000, p 489). I wanted to collect as full accounts as I could, about as wide a range of activities and occupations as possible, to answer my research questions (Section 3.2). As well as contributing to knowledge about adults' quantitative and spatial problem-solving in their everyday lives, I wanted to gather stories that could be used in adult numeracy education, to stimulate discussion amongst students about their problem-solving.

I was looking for a research method that would allow the participants to tell their own stories in their own ways, without me providing them with a pre-determined structure. This was very much an exploratory study: trying to find out what was there. So, for example, I did not want to give the participants questionnaires, because although this would have enabled me to involve a much greater number of people in the study, it would have meant that I only would have obtained the answers to questions I had thought of beforehand.

I could have conducted the group using a semi-structured interview schedule, asking the participants in the group to respond to pre-determined questions, but I wanted the participants to feel free to talk about anything that they wished, in any way they chose, so as to try to access the meanings of mathematics in their worlds (Stanage, 1987; Arthur, 1995).

Phenomenology 'seeks to outlaw any reading (of a situation) which could not be borne out by the indigenous meaning' (Arthur, 1995, p 446). My intention was to 'bracket out' my potentially distorting opinions and beliefs about the field, although I do not think it is possible to do this completely.

> Methodologically, this is a perfectly valid ideal to aim towards, even though it is highly improbable that it can ever be fully reached and regardless of whether, at a further level of abstraction, it makes sense to try to separate noumena from phenomena or essence from manifestation, and accord the former in each pair a higher degree of reality. (Arthur, 1995, pp 447-8).

I told the participants in the Everyday Maths Group that I wanted to look at any maths or number that they used in real life, as opposed to the maths they had learnt at school: what maths they used; how they used it; how they thought about it. I asked them to tell the group about things they do that involve maths or numbers in any way. I said I was interested in the whole situation, and asked them to relate their experiences as stories and to respond to each other's experiences.

Before the first meeting I prepared some printed questions on individual cards to give to the participants when they had ran out of spontaneous stories. Appendix 1 contains the questions that were on the cards. I did not ask the participants the questions directly. I told them that they could look at the cards if they wanted to and choose one to talk about. The purpose of the questions was to act as prompts, in case any of the participants could not think of any occasions when they had used maths or numbers. My intention was not to get all the participants to answer all the questions. I was more interested in the participants telling spontaneous stories about situations that I had not thought of, because I wanted to collect information about as many diverse situations as possible.

The structure of these questions imitates those in the first part of Sewell's study (1981). Sewell asked her participants, in an open way, whether they used any maths in particular situations giving the respondents the opportunity to answer in whatever way seemed appropriate to them. I was particularly impressed with her first question, 'In the supermarket, how do you know that you have enough money to pay for the items in your trolley?' (1981, p 13), because of the range of different answers it produced. Like Sewell, I did not want to frighten my participants and I had promised them that I would not ask them to do any maths, only to talk about their experiences. I did not use Sewell's actual questions, because I felt that they did not represent a balanced set of everyday activities, as I discussed in Section 2.4.4.1. What I took from Sewell was the structure of the questions. But I used a wider range of contexts than she did.

The reason that I wanted to ask my participants open questions was because one of my aims in doing this study was to find 'a wide range of activities and occupations' where quantitative and spatial problems were constructed and resolved by adults in their everyday lives (my first Research Question, see Section 2.5). Rather than assume that I knew the situations where adults constructed and resolved such problems, as authors of surveys have to do, I tried to make my questions open to as many possibilities as I could. As well as being open to a wide range of activities and occupations, the questions were also designed to be open to the many methods of resolution, and the many kinds of solution, that the participants might use and find in their everyday lives (my second and third Research Questions (see Section 2.6).

My questions were meant to encourage the participants to tell stories in their own words and to give as much contextual detail as possible. The questions ranged over as many everyday situations that had a mathematical element of which I could think. They were formulated in situational terms, for example, 'When you were coming out today, how did you decide what time to leave home?' The cards were placed on the coffee table in the centre of the group at each meeting. I thought that these questions had more potential for encouraging the participants to talk about their experiences than closed questions, such as the ones Sewell used in the second part of her study, or those used by other researchers (for example, the National Child Development Study (1997) (see Section 2.4.4.2)). The latter tend to be school maths, wrapped up in simulated everyday contexts, and closed (discussed in Section 2.4.4.2).

I decided to put pencils, paper and some calculators on the coffee table in the middle of the room, in case the participants wanted to write down calculations or use the calculators to determine the answer to a problem. But I was slightly concerned that the participants might interpret the presence of these objects as an indication that I was expecting them to show me formal methods that they could use to calculate.

3.5.3.3 Recording the data

I used audio-recording in the meetings of the Everyday Maths Group, so that I retained an accurate record of what was said, but could concentrate on facilitating the group while it was meeting. I used two tape-recorders, in case one microphone could not pick up everyone in the group.

3.5.3.4 Analysing the data

I transcribed the recordings of the conversations in the Everyday Maths Group. I systematically coded the transcriptions of the group, using Lincoln and Guba's method for developing grounded theory (1985: 344-351). I labelled words, phrases and sentences with codes that described the content. For the first group, I physically cut up the transcript with a scalpel and grouped the pieces of paper in envelopes according to their codes. When a piece of text fitted more than one code, I copied it so that it could be put into all the appropriate envelopes. I then went through each envelope to check whether the pieces of text accorded with each other and with the code. Finally I made a list of the codes and organised them into a schema. For the transcripts of the other three groups, after coding the transcriptions on paper, I simulated the process of physically cutting up the paper and putting the pieces into envelopes by 'cutting' and 'pasting' on a word processor. (See Appendix 3 for the schema for the first group).

Examples of the codes are: 'calculation', 'informal tools', 'reviewing the solution to a problem'. My interests in the data were first, the nature of the quantitative and spatial problems that people construct in everyday life, in a wide range of activities and occupations; second, how these problems are constructed and resolved; and third, what constitute satisfactory solutions to these problems, for the participants. These interests had an influence on the way I categorised the pieces of text. But I also found data I had not anticipated: for example, different kinds of social relationships were prevalent throughout the data and needed codes to identify them.

In Section 3.5.3, I have described and discussed a phenomenological investigation into the construction and resolution of quantitative and spatial problems in everyday life by the setting up of an Everyday Maths Group. I have described and discussed its purpose, its participants and its conduct and the collection and analysis of data from the group. In the next section I describe my further analysis of the data from all three sources.

3.5.4 Further analysis of the data

3.5.4.1 Matrices

When I came to write up the data from the Everyday Maths Group and from my visits to the upholsterers and the gardeners, I found it helpful to produce matrices to enable me to group categories of data. I broke down all the fieldnotes of visits to the upholsterers and the gardeners and the transcripts of the Everyday Maths Group into incidents I had observed and stories that I had been told, for one axis of the matrix and put categories of data as the other axis. Examples of this are in Appendices 5 and 6.

3.5.4.2 Writing as analysis

I also used writing as a further method of analysis. 'Writing went hand in hand with analysis – my own perception is that the physical act of writing ... actually stimulates the process of analysis.' (Nolder, 1992.) I found that the process of formulating the results of my research into written accounts helped me to understand my data better and to see connections between different aspects of the data. As Piaget says, 'I could not think without writing.' (Piaget, 1952.) In this section, I have described two methods by which I took further the analysis of data. In the next section, I discuss the ethical issues of the study.

3.6 Ethical issues of the study

One ethical issue in the study was the respect that was due to the feelings of the participants. When I was inviting women to come to the Everyday Maths Group, I promised them that I would not ask them to do any maths in the group, only to describe numerical or mathematical problems that they had encountered (reported in Section 3.5.3.1). I therefore asked the participants open questions (discussed in Section 3.5.3.2). I did not ask them to do any calculations. A second ethical issue was for the participants to understand the purpose of my recordings and visits. I told all the members of the Everyday Maths Group and Joe and Sean that I was going to write a thesis and papers for publication. I did not discuss this directly with the gardening workers or the upholstery students. With hindsight, I think that I should have done so. Sean and I told the students in the upholstery class that I was interested in adult education, rather than maths, (discussed in Section 3.5.1.1). In retrospect, I consider this action to be unethical, although it was done with good intention. A third ethical issue was the protection of the participants' anonymity by using pseudonyms to refer to them and the places involved in their activities. In the next section, I summarise the chapter.

3.7 Summary

In this chapter, I have set out the aims of my study and described my theoretical stance. I have discussed the methodologies of the study: ethnomethodology and phenomenology. I have described and discussed the design of the three parts of my study: observation and conversations with upholsterers and gardeners at work and discussions in an Everyday Maths Group that I set up, where the participants told stories about their problem-solving in various occupations and other areas of everyday life. I have discussed the ethical issues of the study. In the next chapter, I discuss some methodological issues, which arose during the conduct of the study.

Chapter 4. Methodological issues that arose during the course of the study

4.1 Introduction

In this chapter, I consider some methodological issues, which arose during the course of the study. First, I discuss how I negotiated access to the upholsterers, not very successfully, and to the gardeners, successfully. Second, I report on the composition of the Everyday Maths Group, and what the implications were for the study. Third, I consider issues that arose during the collection of data. Fourth, I discuss other research issues and fifth, I summarise the chapter.

4.2 Negotiating access to the upholsterers and gardeners

When I was negotiating with Sean about visiting the upholstery workshops, I did not communicate effectively with him about what I wanted to do. I had intended to visit his professional workshop a number of times, to observe him and talk with him about how he solved upholstery problems. I was not sure how many visits I would need to make before the data I was collecting became repetitive. Sean first invited me to visit the upholstery class. The students seemed quite happy to show me what they were doing and some of them told me quite a lot about their lives and their experiences of education. When I came to visit the next week, they did not appear to mind and invited me to have lunch with them. But by then I realised that I was not observing expert practice, only an approximation to it, and I asked Sean if I could visit his professional workshop. He agreed an appointment with me and when I arrived he showed me what he was doing and chatted to me about how he learnt upholstery from his father and how his small daughters were beginning to learn from him.

But when I asked him if it would be all right to visit him and the class again, he said, 'Don't burn it out'. He told me that the students had been asking him what I was doing in the class. Sean may have thought initially that I only wanted to make one or two visits to each workshop. I realise that if I had had a more definite plan about what I wanted to do, I could have been clearer to Sean about what my requirements were. Also, I should have asked him to arrange for me to have a group discussion with his students, where I would have explained to them what I wanted to do and asked them whether they were willing to be observed, for a fixed number of sessions. I had asked him for his permission to come to the class, but, as far as I know, he had not asked the students for their consent.

Alternatively, I should have explained to Sean exactly what I wanted to do and asked him to explain it to the students and ask their permission to be observed. It is not clear to me whether it was Sean or the students who were not comfortable with being studied. I decided not to ask to visit the class or the professional workshop again, because I felt that, even if Sean had agreed to being visited again, I did not want to be in a position where I was observing people who felt uneasy about it. I thought that it would be difficult to collect good data in such circumstances. The result is that the data on upholstery is not as comprehensive as the data on gardening or from the Everyday Maths Group. Table 4.1 shows my visits to the upholstery workshops and the activities in which the participants were involved.

Access to the gardeners, on the other hand, was almost trouble free. I visited the gardeners several times while they worked on three gardens. I also accompanied Joe twice when he visited potential customers to do estimates for them. Table 4.3 lists my visits to the gardeners and the tasks they were performing. I do not think that the access was easier because I was any clearer with Joe about what I wanted to do. Joe appeared to enjoy having someone to talk to about his work. I got the impression that he might have been entertaining me, some of the time. For example, when he was calculating the area of a quadrilateral lawn, he involved me in solving the problem (see Section 5.2.2.1). Also when he talked about planting according to the phases of the moon, I was not convinced that he actually did this, because it would have been very difficult to fit into his schedule. But it was a good story and perhaps he wished that he could do this.

The only problem that I had with Joe was that he forgot, twice, that he had arranged with me to meet him at potential customers' houses, when he was doing estimate visits. On each occasion, when I arrived at the house at the appointed time, I could not see his van, but was not sure whether he would have driven there, because both places were very near his house. I knocked at the doors and explained to the potential customers what I was doing. They invited me in and I spent half an hour chatting to them about my work, before

Date	Approx time	Place	Participants	Activities
17.4.97	90 mins	Craft workshops	Sean	Teaching and helping students.
			Beattie	Making false button for button backed chair.
			Carol	Stripping old webbing and nails from an antique armchair.
			Denise	Repairing the frame of a chair.
			Evelyn	Tacking the top fabric onto a settee.
24.4.97	120 mins	Craft workshops	Sean	Teaching and helping students.
			Alice	Finishing caning a chair seat.
			Evelyn	Repairing the frame of a chair.
			Felix	Tacking calico onto armchair.
			Grace	Sewing piping onto cushion for armchair.
			Denise	Repairing frame of chair.
			Beattie	Tacking calico to chair frame.
29.4.97	60 mins	Prof workshop	Sean	Stretching and tacking on the top fabric to the last of a set of 10 dining chairs. Measuring calico against chair seat. Tacking calico to underside of chair seat. Advising Henry.
			Henry	Stripping down a chair in another room.
			Ivan	Working in another room.

Table 4.1. Timetable of observations of upholsterers.

Date	Approx time	Garden	Activities	Workers
23.4.97	75 mins	Spruce Grove. Small half garden behind large semi-detached house.	Finishing patio. Sorting out tools, materials and plants to take to Larch Place. Preparing bed for lawn. Arranging plants in flower beds.	Joe, Ben, Gerry, Freddie
23.4.97	90 mins	Larch Place. Very small quadrilateral garden behind terraced shop used as office.	Measuring area for lawn. Spraying roses. Planting up containers.	Joe, Ben, Gerry, Freddie
13.6.97	90 mins	Yew Tree Road. Large long garden behind large terraced house.	Tying rosebush to deck. Removing bindweed. Finishing deck. Buying weed-suppressing sheet and placing it under deck. Covering lawn bed against rain.	Joe, Ben, Gerry, (Mick)
13.6.97	90 mins	Pine Road. Largish square garden next to semi-detached house.	Estimate for maintenance: dig over beds, feed, divide some plants, dead-head, trim back tree, do edges of lawn, clip privet hedge.	Joe, Ms. Beech
14.6.97	90 mins	Fir Tree Grove. Small front garden, smallish back garden and roof terrace Terraced house.	Estimate: re-lay back lawn, install automatic watering system, pave area by back gate, paint preservative on shed, fix restraining wires on fence for climbing plants, mulch and plant flower beds, construct wood or metal fence for flat roof, feed, aerate and seed front lawn, replace gate and gate-post, maintenance.	Joe, Mr and Mrs. Neem and two children
16.6.97	15 mins	Yew Tree Road, as above.	Preparing bed for lawn.	Ben, Gerry
16.6.97	60 mins	Yew Tree Road, as above.	Bringing turf through house from street. Laying turf for lawn.	Joe, Ben, Gerry, Lee
17.6.97	60 mins	Yew Tree Road, as above.	Laying edges of lawn. Finishing deck. Staining caps for fence posts. Pruning wisteria at house opposite.	Joe, Ben, Gerry, Lee

Table 4.2 Timetable of observations of gardeners.

Joe arrived. I was lucky that neither customer seemed to find this an intrusion. Where the gardeners were actually gardening, in two cases the owners were absent, so that Joe did not have to account to them for my presence. In the Larch Place garden, Joe introduced me to the owner as a time and motion study expert (see Section 6.4.1.1.1.).

4.3 The composition of the Everyday Maths Group

4.3.1 Homogeneity of the group

The advantage of creating the Everyday Maths Group in the way that I did is that many of the people already knew me and trusted me and therefore appeared to feel able to talk openly about their lives and about maths, which can be an emotionally charged subject for some people. The group was homogenous in terms of social class and gender, which also reflected my own. The participants and I created a very warm, supportive and friendly atmosphere. There was a feeling of empathy and commonality of experience, which I think enabled the women to feel that their experiences were legitimated and validated.

The group was also deliberately skewed towards women who were not overtly confident about maths. I did not invite the few women I know who did not appear to have much difficulty with learning and using mathematics. I thought that their competence might intimidate the other participants. But the group did not include people who were really terrified of maths and who did not even want to talk about it, because they refused to come to the group. The group was not homogenous in terms of ethnicity, but I saw this as an advantage in terms of being able to collect data about a wide range of activities.

4.3.2 The educational and occupational experiences of the participants

As I discussed in Section 3.5.3.1, the weakness of finding participants for the Everyday Maths Group in the opportunistic way that I did, was that the group cannot be said to be representative of any larger population. The group was constituted of participants who had all received at least twelve years of education: all of them were graduates or undergraduates. Many of them had also had professional training. However, only one of them had studied maths beyond GCSE level, or its equivalent in other countries, and all but one of the participants were working in, or studying, non-technical areas. Table 4.3

lists educational and occupational profiles of the participants. The group was therefore not comparable with the participants in Hutton's (1998a, 1998b, 1998c) or Hoyles' et al (1999) studies: nurses, airline pilots and bank employees probably all use more maths in their work than the non-maths teachers, social workers, librarians, museum workers, and people in administrative, catering or cleaning work, who participated in the group. Table 4.3 shows brief educational and occupational profiles of the participants.

I had anticipated that the general educational level of the participants might mean that they would use more formal maths in their everyday lives, than those participants, in other studies, who tended to have had less education (Lave, 1988; Millroy, 1992; Nunes et al, 1993; Masingila, 1996; Harris, 1997b). This did not turn out to be the case: in the stories they told, the participants in the Everyday Maths Group mostly reported using informal methods and tools and tending to estimate rather than calculate, as did the participants in other studies.

4.3.3 Refusers

I had contacted eight more people who did not attend any sessions of the Everyday Maths Group. Three of them said that they never used maths, and were unwilling to talk about it in a group. Denying that they use any maths accords with Harris's (1997b) findings that people see the maths they use in everyday life as 'common sense', and only what they cannot do as maths.

One person did not reply to my telephone message, asking if they would be interested in attending the group, for three weeks and then declined to come. Four women expressed themselves very willing to help with the research, but at the last minute phoned to say they could not come to the first meeting of the group, and did not attend subsequently. Table 4.1 shows the reasons people gave for not coming to the group. This level of refusal did not surprise me: reference has already been made to Sewell's (1981) difficulty in finding participants for her research into the use of maths by adults in daily life and to Buxton's (1981) identification of maths anxiety. I have taught many students and talked to many other adults who suffer from anxiety about maths. McDermott (1993) suggests that people's success in practices is entirely determined by the social situation in which they find themselves and that there are two legitimate routes within each situation:

Participant	Education	Occupation
Cathy	Graduate. Qualified librarian.	A librarian in an FE college.
Claire	MA in education.	A lecturer in adult literacy and ESOL in a college of FE.
Eileen	MA in museum studies.	Working on trains for a catering company, whilst applying for a professional museum job.
Eleanor	PhD student in IT and psychology.	Student. Previously worked as audio-visual technician and library assistant.
Jean	Graduate and qualified social worker.	Social worker working with mental health patients.
Meera	Undergraduate in religious studies.	Student.
Rhiannon	Undergraduate in comparative religion.	Student and working part-time as a cleaner and in a bar.
Ruth	A degree in social science.	An administrator in a hospital. Previously worked in a variety of administrative jobs.
Sheda	An arts degree from Somalia. An MA in linguistics.	Part-time tutor in ESOL and IT in an FE college and community projects.
Shelley	A degree in science from Bangladesh. Studying for a degree in education.	A lecturer in ESOL, IT and numeracy at an FE college.
Vera	A degree in history of art.	Teaching history of art and German part-time in adult education and to individual children.

Table 4.3 Profiles of participants in the Everyday Maths Group

Reasons given for refusal	No of people
Found out the day before that they had to work.	2
Phoned on the morning of the group to say they had migraine.	2
Flatly refused (no reason given).	3
(Did not reply to answerphone message until 3 weeks later.)	1
Total	**8**

Table 4.4 Refusals to attend the Everyday Maths Group

Participant	Attendance			
	11th May	8th June	10th Aug	5th Oct
Cathy		*		*
Claire		*		*
Eileen		*	*	*
Eleanor		*		*
Jean		*	*	*
Meera		*		
Rhiannon	*	*	*	
Ruth	*	*		*
Sheda		*		
Shelley		*		*
Vera			*	*
Totals	**2**	**10**	**4**	**8**

Table 4.5 Attendance of the participants at the Everyday Maths Group

success and failure. To apply this to the community of practice of school maths, a few people are successful but many are not. The failure route is 'legitimate' (McDermott, 1993): it is socially accepted that the majority of people cannot do maths, and this includes more women than men (Harris, 1997b). But failure can still carry with it feelings of inferiority, accompanied by anxiety and fear, which has often been an intrinsic part of the community of practice of the maths classroom (Buxton, 1981; Bibby, 2002). These were probably all contributory factors in the decisions people made not to come to the group.

4.3.4 Attendance at the Everyday Maths Group

Altogether eleven women attended at least one of the meetings of the group. The group met four times in 1997, on 11th May, 8th June, 10th August and 5th October. Table 4.4 shows the attendance at each session of the group.

Each meeting lasted approximately one and a half hours. This seemed to be a natural length for the group. The participants had run out of steam by this time and needed the lunch that I had promised them.

4.4 Collection of data

4.4.1 The upholsterers and gardeners

When visiting the upholsterers, I took the role of a peripheral participant observer (see Section 3.5.1.2). I watched them work, asked them questions about what they were doing, how and why they were doing things, and listened to their conversations with each other. When I visited Sean in his professional workshop, he explained to me what he was doing and what he had done, as he worked. He described his philosophy of teaching and learning to me. The upholstery students also talked about their experiences of education and their feelings about it, as well as about the upholstery tasks they were performing. They showed me and told me about what they were doing and what they had previously done. Although I had had some reservation that the student upholsterers' practice was not expert, I found that observing the upholstery class and talking to the students was very useful for me. The students were all working on their pieces of furniture at different stages of the upholstery process, so that I was able to get an overview of the whole process, as well as being instructed in detail on the caning process by one student and on how the top fabric is put onto a settee by another.

In my visits to the gardeners, I took the role of a peripheral participant observer, as I had with the upholsterers (see Section 3.5.1.2). I watched them work, asked them questions about what they were doing, how and why they were doing things, and listened to their conversations with each other. The gardeners showed and explained to me what they were doing and what had been done. Joe, whose gardening firm I was observing, talked to me about his preference for measuring with his body, the herbal properties of plants, the appropriate phases of the moon for planting and harvesting, the difficulties of managing his staff and the building contractor, and the preferences and idiosyncrasies of his customers and their neighbours. Joe's workers also explained to me what they were doing.

Although my plan was to investigate the contribution that spatial relationships made to the resolution of upholstery and gardening problems, it seemed more practical to collect as much information as possible about everything they were doing and to work out what was mathematical and what was spatial, during the process of analysis. I conversed with the upholsterers about upholstery tasks and education and with the gardeners about gardening, plants and their medicinal properties, types of soil, the weather, the path of the sun, fencing, what the customers wanted and how Mick, the builder, had behaved. I found that it was difficult to 'catch' the upholsterers or gardeners calculating. They often seemed to have measured or calculated something just before I arrived. When I could deduce that some maths had been used, I was able to ask them to describe what they had done, or to demonstrate it to me, but I had missed the original event. There may have been many other occasions when I was not aware of calculations that had been done. But this is a problem with any observational research method (Brown and Dowling, 1998). Through the analysis of the data, I abandoned the idea of concentrating on spatial relationships and focussed on problem-solving instead. Although there were examples of the use of spatial relationships in the work of the gardeners and the upholsterers, I became much more interested in the construction and resolution of problems, which of course included spatial problems. It seemed to me that by far the most important ongoing problem that Joe had to solve, and what he found most difficult, was the management of his and his workers' time, so that he earned enough from his customers to pay himself and his staff and covered the cost of the materials and his expenses. All the other quantitative and spatial problems that Joe had to solve were contributory problems to the overall one of the management of time and money.

4.4.2 The Everyday Maths Group

4.4.2.1 Use of resources

I put calculators, paper and pencils, on the coffee table in the centre of the group, in case the participants wanted to use the calculators or write down calculations to find the answer to a problem (see Section 3.5.3.4). I was slightly concerned that the participants might interpret the presence of these objects as an indication that I was expecting them to show me formal methods that they could use to calculate, but this did not happen. One participant, Rhiannon, wrote down a calculation at my request after she had described it to the group. It did not represent a standard school method. Another participant, Ruth, used a calculator to show the group the method she had learnt to use with a calculator at work. The other participants ignored the pens and paper and the calculators.

4.4.2.2 Audio-recording

The participants found the idea of being tape-recorded rather unnerving at first. So I had the tape recorders switched off at the beginnings of the meetings, to allow the participants to settle in and decide what they wanted to talk about. When they had identified events they wanted to recount, the participants gave their permission to be recorded, accepting it as necessary to the research. I then switched on the tape recorders. Occasionally I switched the tape recorders off during the group, if someone arrived late and I wanted to introduce them to the rest of the group, or when I thought we had exhausted what the participants had to say. Sometimes they started telling more stories at that point and I requested their permission to switch the recorders on again and asked them to repeat the beginning of the story.

4.4.2.3 The effectiveness of the research method

The Everyday Maths Group proved to be an excellent way of collecting women's accounts of their experiences in a whole range of situations, many of which had not been anticipated by me. Some of the participants said at the beginning of a session that they could not think of anything to say. But I found that all the participants did produce stories. They were stimulated by each other's stories, or by the question cards, into remembering and feeling confident to talk about their own experiences. The participants together talked for about an hour and a half each time and seemed to enjoy the discussion.

The participants in the group talked about other communities of practice in which they were involved, in other parts of their lives. The accounts they gave were therefore constructed *post hoc:* they were of the participants' perceptions of their actions and understandings. I believe that the stories the participants told were authentic constructions of their perceptions of their experiences. This was partly because my data were consistent with the findings of other studies of everyday cognition (Lave, 1988; Lave and Wenger, 1991; Saxe, 1991; Nunes et al, 1993). It was also because the participants told contrasting stories: they did not copy each other. Also the problem-solving that they described was very different from the kind of problem-solving that is required in schools.

The open-ended nature of the questions enabled the participants to talk about what was important to them, using their own words, language and frameworks to describe their experiences. Although I had not specifically intended to collect data about the participants' feelings and identities, I found that these were an intrinsic part of their stories. The Everyday Maths Group process appeared to be a particularly effective way of collecting such data.

4.4.2.4 The socio-cultural contexts of accounts

I encouraged the participants to give all the details of the activity and I therefore was able to collect the socio-cultural contexts of the problems that the participants constructed and resolved. They did not just describe calculations and measurements, but recounted why they had done them, mentioned other people involved in the activity, talked about their feelings, and judged whether they had been successful or not.

4.4.2.5 The diversity of the data

As I discussed in Section 3.5.3.1, I thought it was very unlikely that the participants in the Everyday Maths Group would have talked to each other about the maths they used in everyday life, before meeting in the group. The stories they told were therefore more likely to be fresh, rather than rehearsed. This turned out to be the case: the participants were stimulated by each other's stories to tell of their own experiences, but they did not often say that they had had the same experiences as each other. In fact their stories were often opposites of each other.

I gave the participants some printed questions, on individual cards, that I had prepared before the first meeting (see Appendix 1). As I discussed in Section 3.5.3.4.1, the purpose of these questions was to stimulate the participants' memories, if they ran out of spontaneous stories. They were not intended to be answered by all the participants, because I was more interested in collecting stories that were as diverse as possible, to cover as wide a range of situations and activities as possible, to provide answers for my first research question and to build up a collection of stories that could be used in adult numeracy classes to encourage students to recognise their own problem-solving in everyday life. The result of using this method was that twelve out of the twenty-one questions were addressed by the participants, some of them by more than one participant, but there were also many stories told which were not in response to the questions. The data I collected from the group were very diverse, as I had wanted them to be. What I had not realised, when I planned the study, was that this diversity would make the analysis of the data difficult. If I had collected eleven stories from the eleven participants about one issue, for example about how they managed their money, I would have had a lot of data with which to do comparative analysis. As it is, although there are some comparable stories, most of the data are not analogous.

4.5 Research issues

4.5.1 Elusiveness of mathematics

The mathematical part of everyday problem-solving was elusive in two ways: the participants may not have been aware, in some cases, that they were using maths, and when they were calculating mentally, it was not possible to observe that. The maths that people do in everyday life is structured in socio-cultural activities, not in mathematics (Lave, 1988) and therefore it is the activity rather than the mathematics of which people are aware. I sometimes found that I myself was not aware of the maths in an activity while I was observing it. It was only when I wrote and analysed the fieldnotes that I became aware of the mathematical content. For example, in the upholstery class, Alice recounted to me the set of procedures she had followed in replacing the canes in the seat of a chair and I understood them as a set of procedures. I wrote them down and drew diagrams (Fig. 5.4) immediately after the visit, and it was only in doing so that I realised that she must have been using a sense of geometrical pattern to make sure she was placing the canes in the right directions, parallel to, at right angles to, and at 45 degrees to, the back of the chair, to produce the traditional pattern she wanted. She may not have been thinking in those mathematical terms, but, nevertheless, she demonstrated a geometrical sense in getting her canes in the right positions to produce the required pattern. She was probably not aware of this geometrical sense and neither was I at the time we were talking. This is consistent with Harris's (1997b) findings that women do not always recognise that they are using mathematical thinking in their activities.

4.5.2 Invisibility of mathematics

When people do 'mental' calculations, there is nothing to observe or hear, except what they say out loud, which may only be the results (Tomlin, 2002). They can be asked to explain their methods of working, but this is then *post hoc* to the event. What is collected is therefore an account of their perceptions of what they did, rather than an observation of them doing it, which would be the researcher's perception of the event.

4.5.3 Researcher effects

It is not possible to carry out observational research, or interviewing, without having an effect on the behaviour of the people being observed, or on what interviewees choose to disclose to interviewers (Brown and Dowling, 1998). I believe that my presence in the upholstery class and Sean's workshop probably only had a minor influence on what the upholsterers were doing when I was there: Sean and the students appeared just to get on with what they normally did: doing upholstery, helping each other and chatting. Nevertheless, I was aware that what they chose to tell me must have been influenced by their perceptions of me. 'You can rarely discount completely the effect of your presence in a situation as an observer.' (*Ibid*, 1998, p 8.)

Sean had told the upholstery students, with my agreement, that I was researching adult education, not how people use maths in their everyday lives (see Section 3.5.1.2), because we thought that some of the students might feel very anxious about maths. In retrospect, not being totally truthful with the upholstery students was a mistake. Judging by the responses of the participants and refusers of the Everyday Maths Group, some of the upholstery students might have been anxious about talking to me at first, but others may have had interesting stories to tell me. Some might have wanted to share their experiences of trying to learn maths at school, which was not my primary interest, but might have acted as a gateway to talking about what they do in their everyday lives and upholstery in particular. Telling them that I was interested in adult education made it difficult to ask very probing questions about measurement and spatial relationships. The effect it had on the students was for them to tell me what a good teacher Sean was and that his class was much better than other experiences they had had of education. In retrospect, I think it might have been better to have told the students what my real interest was. If they had said to me that they were not doing any maths, I could have dealt with it by saying that if they showed me what they were doing, I might be able to see some maths in it of which they were not aware.

Whilst we are aware of some of the knowledge we have, we also have other knowledge of which we are unaware (Tomlinson, 1998). The effect of being observed at work, and especially of my asking questions, may have made the workers aware of knowledge that they previously held without being aware of it. This in turn may have altered their behaviour.

For example, Joe was mixing up spray for the roses, something he must have done many times before. I asked him if he had to measure it carefully. As far as I could see, he had not looked at the directions on the packet when he started, or measured the amount of water. I asked Joe about being careful because I expected him to tell me something about the ratio of powder to water, something mathematical. He said he should measure carefully, but he trusted the manufacturers not to sell anything unsafe. He then read out all the chemical ingredients and the directions on the packet, which included instructions to wear gloves and a mask. Joe was wearing gloves but no mask. He sprayed one rose and then said he might be contaminating me (it was a very small garden with high walls) and he stopped. Joe was doing something that he had probably done hundreds of times before. The first time he did it he probably had read the directions and worked out what size of container to use and how much water to put in it. He did not need to work this out every time he mixed the spray. He may have made a decision then about which safety precautions it was worth following, or he may have subsequently forgotten about the safety precautions. If I had not asked him, he would not have become conscious of them. So my question may have had an effect on his behaviour.

I felt on one occasion in the Everyday Maths Group that what one of the participants said may have been influenced by her perception of me as a mathematically capable person, even a representative of the mathematical establishment, or the mathematics teaching establishment, possibly without being aware of it. Cathy was talking about catching trains and she said that she 'should' look at the timetable, but she never does, she allows herself enough time just to get on the next train that comes (see Section 5.2.5.2). I think the word 'should' may reveal Cathy's perception of what I might think she ought to do: behave rationally and efficiently by using the train timetable. Or it could be that part of her thought she should do this, but she was choosing to ignore it. This incident made me aware that what the participants chose to tell the group, how they chose to tell it, and how they constructed their stories, must have been influenced by their perceptions of me and each other. But 'Qualitative research cannot be made researcher proof.' (Ball, 1990, p 167.)

4.5.4 Temporarily losing the role of researcher

There were two occasions when I unintentionally slipped out of the role of researcher, back into the role of teacher. Joe complained to me that garden suppliers had been obliged by the European Union to switch the dimensions of their products to the metric system. He said that he was used to using his body to measure things and that this fitted into the Imperial system of measurement, which is based on the human body. Instead of just collecting Joe's statement as data, I suggested to him that he could find ways to relate metric measurements to his body, something I have done many times with students. The effect on Joe was to surprise him and he did not say any more about measurement, at that time. If I had not changed my roles, from researcher to teacher, I could have followed Joe's account by probing for more information, for example, asking him whether he found measuring with his body gave him accurate enough estimates in all situations. I therefore missed the opportunity to collect some useful data.

On another occasion, in the Everyday Maths Group, Ruth mentioned using a slide rule at school and Jean asked what a slide rule was. I dug mine out and instead of asking Ruth to explain its use, I proceeded to demonstrate it to Jean and the rest of the group, becoming a teacher instead of a researcher. When I realised what I had done, I said to Ruth that I should have asked her to explain it. I asked her if she wanted to say any more about it, but she declined. I therefore did not collect any more information from her about her experience of using slide rules. It was difficult for me to avoid completely this slipping from the role of the researcher to the role of teacher, as I have far more experience of being a teacher than a researcher.

4.5.5 Respondent validation

I attempted to use respondent validation (McCormick and James, 1983) to effect triangulation on my data, by asking Joe and Sean if they were willing to read the first draft of a paper I wrote about the upholsterers and gardeners (Colwell, 1999a). They both said that they were willing. Joe brought it back to me, saying it was fine and Sean sent it back to me through an intermediary with no comments, so I do not know whether he did read it and whether he thought it was an accurate rendition of his work or not. I had hoped for more detailed feedback than this.

I also tried to effect triangulation through respondent validation (McCormick and James, 1983) on the data from the Everyday Maths Group. After I had written the first draft of a paper about the data from the group (Colwell, 1998), I asked the members of the group who were mentioned in the paper, Claire, Shelley, Sheda and Ruth, if they would be willing to read it and give me feedback. They took copies away and at the next meeting of the group they gave some brief feedback, 'It was interesting,' and 'It seemed quite accurate.' In retrospect, I believe I could have encouraged them to expand on these statements, but at the time I did not do so. It perhaps would have been easier for them to give more detailed feedback, if I had given them some guidance about what I wanted.

4.5.6 Schedule of data collection and analysis

I called each meeting of the Everyday Maths Group when I expected to have finished transcribing the tapes from the previous meeting and when I was able to fit it in with other commitments, including my visits to the upholsterers and gardeners. After the fourth meeting, I had a lot of data to analyse, from the group and from my visits to the upholsterers and gardeners. I had intended to stagger data collection and analysis, as recommended by Ball (1990), so that each stage of data collection would be informed by the analysis of the previously collected data. So my intention was to analyse the transcripts from the four meetings of the group and the fieldnotes from the visits to the upholsterers and gardeners and then to conduct more meetings of the group and do more visits to the upholsterers and gardeners. In the event, the analysis of the data took far longer than I had anticipated and, having done it, I decided that I had a sufficiency of data. So the decision to exit from the field was taken on an *ad hoc* basis. As this was an exploratory study, I do not think that this lack of planning affected the outcome of the study. In the next section, I summarise the chapter.

4.6 Summary

In this chapter, I have considered methodological issues that occurred during the course of the study. I discussed my negotiation of access to the upholsterers and the gardeners: a difficulty arose with the upholsterers, but access to the gardeners was unproblematic. I reported on the composition of the Everyday Maths Group and how it affected the conduct of the group. I discussed the collection of data and its quality and I considered a range of research issues. In the following two chapters, I report on the data I collected and develop a model of problem-solving which demonstrates the relationship between the socio-cultural contexts of the activities in which problems arise, the complex, cyclical, logical structures of problems and their solutions, and the contribution made by the individual problem-solver.

Chapter 5. The development of a model to reflect the socio-cultural contexts and structures of everyday problems and their solutions

5.1 Introduction

In Section 2.6, I set out my research questions, as follows:

1. How do the socio-cultural contexts of a wide range of activities and occupations impact on everyday quantitative and spatial problems and their solutions?
2. How are problems and their solutions structured?
3. How does the agency of individuals interact with the socio-cultural contexts in the problem-solving process?

In this chapter and the next, I report on the findings of the study. In this chapter, I examine the contexts and structures of my participants' everyday quantitative and spatial problem-solving, focusing on my first and second research questions. The methods I used to collect the data in this study resulted in me accumulating events and stories that had quantitative or spatial elements. But, in the main, these events and stories were structured in activities, not in mathematics (Lave, 1988), so that the participants in the study may not have always been aware that their experiences had a mathematical content. In a sense, I could be accused of mathematizing (Hoyles et al, 1999) everyday events. My answer to this is that people speak grammatically all the time, albeit sometimes in a colloquial grammar, but are not necessarily able to parse their own sentences into grammatical elements. Similarly people behave mathematically in the course of their everyday lives, without necessarily being able to assign mathematical terms to what they are doing. The ways in which they think and behave mathematically could be described as a colloquial form of mathematics: it is understood by the other actors in the situation in which it is used, but it is different from the maths taught in schools.

I developed a new socio-cultural, cyclical, logical model (Fig. 5.1), derived from the data, to explicate the relationships between the different stages of problem-solving and the socio-cultural contexts. This model is useful for the better understanding of the data, because, as a visual tool, it enables the reader to see holistically the four stages of problem-solving and their relationship with each other and with the socio-cultural contexts of the activities in which the problems arise and are resolved.

Although my study focused on problem-solving in everyday life, not mathematics education, I became aware, through analysing my data, of differences between the construction and resolution of problems in everyday life and school maths problems. I am using the term school maths, in the same sense as Nunes et al (1993), to designate the maths or numeracy taught in educational institutions: schools, colleges, adult education provision and training organisations. I discuss the differences between everyday and school maths in this chapter. In Chapter 7, I discuss the implications of these differences for adult numeracy education.

In the next chapter, I focus on my third research question, examining the participants' individual contributions to problem-solving, concentrating on their previous experiences, emotions and identities, and their influence on the construction and resolution of problems. I develop my model further to include these aspects of problem-solving. In this chapter, I first consider the socio-cultural contexts of the problems that the participants constructed and resolved.

5.2 The socio-cultural contexts of problem-solving

In this section, I formulate a model of everyday problem-solving directly from the analysis of my data (Fig. 5.1). The periphery of the model represents the socio-cultural contexts in which the problems in the study were embedded. The centre of the model represents the variety of routes through four stages of the logical construction and resolution of problems that I found in the data and which I will address in Section 5.3. The purpose of this model is for the reader to be able to see holistically these aspects of everyday problem-solving and the relationship between them. The problems in the study were not constructed or resolved in isolation: they were structured within activities in which they were involved, within socio-cultural contexts (Lave, 1988; Lave and Wenger, 1991; Wenger, 1998). In interrogating the cultural context of goals which emerged from activities, Saxe (1991) identified four parameters: activity structures, social interactions, artifacts and conventions, and prior understandings (Fig. 2.2). The participants in my study were acting in relationship to other people, using tools and following the conventions of the communities of practice of which they were members (Saxe, 1991;

Lave and Wenger, 1991). While finding Saxe's (1991) model useful, I have modified his terminology. I am using the term 'activities' rather than 'activity structures', because it seems to me that problems arise out of the participants' activities, rather than any particular structures. What Saxe (*Ibid*) calls 'emergent goals' (p 17), I am calling 'problems' and their 'resolutions'. I am using the term 'tools' rather than 'artifacts' (p 17), because an artifact is something that has been made. Although some of the tools that the participants used in their problem-solving were manufactured tools, they also used other things as informal tools (see Section 5.2.5.3). 'Tools' therefore seems a more appropriate word than 'artifacts' to suit my data. To Saxe's 'conventions' (*Ibid,* p 17), I have added formal and informal methods of problem-solving, some of which were idiosyncratic. Saxe uses the term 'social interactions' (*Ibid,* p 17), but I found that 'social relationships' is more appropriate for my data. The participants did not just interact with other people, although they did that. Their relationships with other people influenced how they constructed and resolved problems. I consider the effect of relationships on problem-solving in Chapter 6. I have not used Saxe's fourth parameter, 'prior understandings' (*Ibid,* p 17) in this model, because it seems to me, as I discussed in Chapter 2, that this is not a socio-cultural parameter, but an attribute of the individual. I also consider this in Chapter 6.

I have expressed my first research question (see Section 5.1) in terms of quantitative and spatial problem-solving, rather than mathematics, because I wanted to make my focus the whole contexts of the problems that the participants constructed and resolved, rather than a narrower focus on calculations. It was the contexts which made the problems meaningful to the participants (Lave, 1988; Nunes et al, 1993). The contexts influenced how the problems were constructed, the ways in which the participants set about resolving them and what constituted satisfactory solutions for them. The participants in the study did not perform isolated calculations, as students are required to do in mathematics classrooms; they constructed and resolved quantitative and spatial problems within the contexts of their everyday activities in the different communities of practice to which they belonged (Lave and Wenger, 1991).

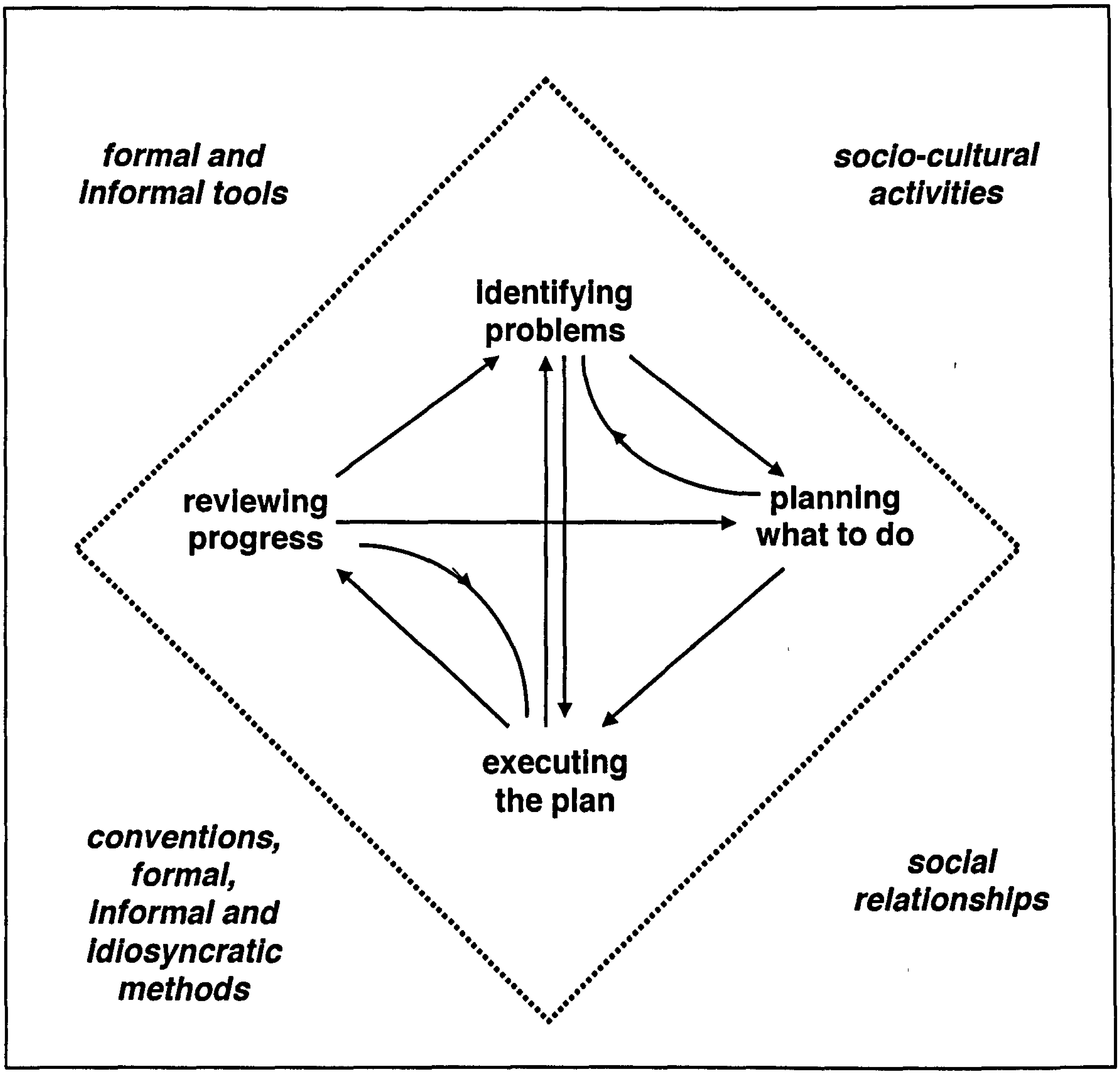


Fig. 5.1 The complex, cyclical, logical structure of problem-solving in socio-cultural contexts

In the following sections, I consider the socio-cultural contexts of the problems the participants constructed and resolved: the activities in which they were engaged, their methods of problem-solving, the tools they used and what constitute satisfactory solutions to them. I discuss how these differ from problem-solving in school mathematics.

5.2.1 The communities of practice to which the participants belonged and the activities in which they were engaged

First, I give an overview of the kinds of problems, which the participants reported upon constructing and resolving, during the course of the study. The problems that I collected had quantitative or spatial components: they involved counting, remembering numbers, calculation, estimation, measurement and orientating objects in space. But the problems the participants addressed were embedded in the activities in which they were engaged in the communities of practice of which they were members. They involved upholstery and upholstery students and their tutor, gardens, gardeners and gardening customers, and, for the members of the Everyday Maths Group, a very wide range of communities of practice and everyday activities.

The upholsterers stripped the old upholstery off chairs and settees, repaired or altered the frames if appropriate, attached canes, webbing, springs, two kinds of stuffing, hessian, calico, top fabrics, buttons and trims. Each of the upholstery or caning materials had to be of the appropriate size and strength and orientated appropriately to the chair or settee. Sean, the professional upholsterer, had also to manage the cost of his work, including his time. The gardeners replaced fences, gates and trellises, built patios, walls, steps, decks and stands for sheds, made paths, laid and mowed lawns, planted and weeded flower beds and containers, and pruned shrubs. As with upholstery, each of the landscaping or gardening materials had to be of the appropriate size and strength and orientated appropriately in the garden. In addition, Joe, the gardener had to manage the cost of the work, including his own and his workers' time. The members of the Everyday Maths Group were also members of many different communities of practice, in which their activities took place, for example in their places of work or study and their families (Wenger, 1998). When recalling their experiences, the participants did not present abstract calculations and then think of a context in which they might use them. They told stories about incidents and routine practices in their lives, which involved some quantitative or spatial thinking. But they described the whole socio-cultural contexts of this thinking. These socio-cultural contexts of the quantitative and spatial problems that the participants constructed and resolved were formed by the wide range of different communities of practice to which the members of the Everyday Maths Group belonged.

The members of the Everyday Maths Group reported catching trains and planes, serving the public with food or sports tickets, buying food, cloth, clothes and furniture, managing their time and money, making and keeping appointments, praying according to a schedule of positions of the sun, cooking and making cakes, putting up shelves, sitting examinations, doing different kinds of crafts, dancing, drumming, swimming, reading maps and finding their ways to unfamiliar places, remembering (and forgetting) telephone and Personal Identification Numbers and recording television programmes. Each of these activities involved using numbers or mathematics in some way: remembering numbers, counting, calculating, estimating, measuring, or spatially orientating themselves, objects or materials. The level of mathematics was fairly basic: the mathematically most difficult problem in the study was calculating the area of a quadrilateral lawn (Fig. 5.2).

The range of activities in which the participants were engaged is important. Other studies have focused on particular communities of practice (Lave, 1988; Lave and Wenger, 1991; Saxe, 1991; Millroy, 1992; Masingila, 1993; Nunes et al, 1993), (see Section 2.4). In this study, I focused on upholsterers and gardeners; in addition, the Everyday Maths Group enabled me also to collect data from the wide range of situations in which the members of the group were involved. Part of answering my first and second research questions (Section 2.6) required the documentation of problems in everyday life that the adults constructed and resolved, so that this could be used to inform adult numeracy education. I intend to do this in the near future.

In traditional maths education, problems are calculations with added context. The real context for students solving maths problems in a classroom consists of the textbook or worksheet, their relationships with the teacher and other students, their history of learning mathematics, the school and how society views and treats maths education. But teachers, textbook writers and examiners construct problems with supposedly real life contexts, to try to make the mathematics more meaningful to the students and to give them experience in problem-solving. For example Cox and Bell (1985) presented different ways of expressing time and demonstrated the calculation of intervals of time and then posed a series of problems for students to practice using this knowledge, with such contexts as a sponsored silence, cycling to a friend's house and doing homework (pp 146-7). These contexts were invented by the authors and may or may not be of relevance or interest to particular students. But the students will not feel that they have ownership of the problems, because they have not constructed these questions themselves (Burton, 1984; Lave, 1988). A fundamental difference between such traditional school maths problems and the problems constructed and resolved in the study was that the participants in the study identified or constructed their own problems out of what was important to them. They therefore owned the problems.

5.2.2 Methods of problem-solving

I turn now to consider one aspect of the socio-cultural contexts of the problem-solving in the study: the methods that the participants used, addressing my first research question (see Section 5.1). In this section, I argue that using informal methods to resolve problems was far more prevalent in the study than using standard school methods.

5.2.2.1 Using formal methods of problem-solving

The participants had all received at least 10 years of maths education. But in most of the situations I observed, or that were reported to me, the participants chose not to do exact calculations. When they did do calculations, they often did not use the standard methods taught in schools, confirming what Lave (1988) and Nunes et al (1993) found. There were just two examples in the data of the participants using school algorithms or methods. In the Everyday Maths Group, Eileen described using an algorithm taught in schools, when she was serving food on trains and neither a till nor a calculator were provided for her use. She found that when a group of people ordered a great number of different things, she needed to resort to pencil and paper and a school algorithm to total up the prices.

> It's when people come in and they are buying for about five or ten (people) and they want one of those and one of those and one of those and one of those. They get this huge pile. And then I usually get a piece of paper out.

In those situations, she used the algorithm she had learnt in school,

> That's how I add up and I carry my numbers over. So otherwise I start to forget how much I have carried over. ... because I get lost otherwise. I start to forget

whether it was a 3 or 4, so I have to go right back to the beginning and start again.

This was the one example in the data of a participant using a school algorithm. I only observed one other participant using a school method of calculation. Joe was measuring up for a lawn that was to be turfed (Fig. 5.2). Although he must have calculated the areas of many lawns, to order the appropriate amount of turf, this may have been the first time he had tackled a lawn that was quadrilateral in shape. He treated the quadrilateral as a triangle and a rectangle. He asked me whether he could calculate the area of the triangular part of the shape by considering it as half a rectangle. Joe was probably drawing on what he had learnt at school: that irregular polygons can be divided up into rectangles and triangles to calculate their areas; and that triangles can be treated as half rectangles. He might have felt slightly unsure of whether he was correctly remembering this school knowledge. Or he might have asked me because he knew that I was interested in the mathematical aspects of his work. Joe and Eileen were the only two participants in the study who appeared to use mathematical conventions they had learnt at school.

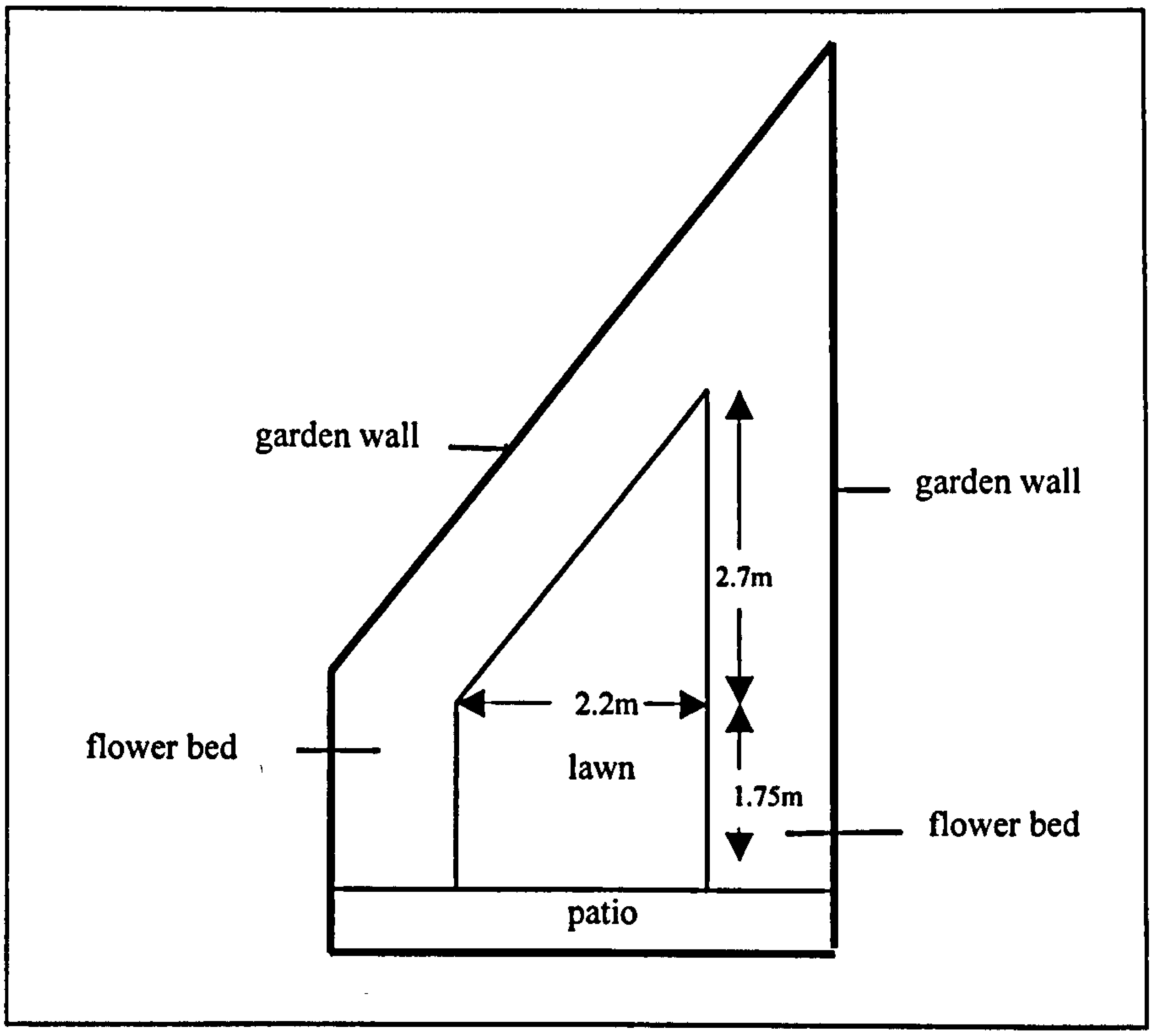


Fig. 5.2 The Larch Place garden

5.2.2.2 Following conventions

In many of the situations where the participants constructed and resolved problems, there were conventions (Saxe, 1991) within the communities of practice (Lave and Wenger, 1991, Wenger, 1998) for solving them. This was particularly true of the working situations: Joe and his workers were inheritors of thousands of years of gardening practice, Sean and his students of hundreds of years of upholstery practice. They both seemed very conscious of this, Joe talking about the herbal properties of plants and planting and harvesting according to the phases of the moon and Sean organising outings to stately homes for his students to view examples of furniture produced in previous centuries. In the Everyday Maths Group, where the participants were recounting experiences of their work, they were usually describing the conventions of the communities of practice in which they worked, in the way they constructed and resolved problems.

When Eileen was serving food on trains, the catering company that employed her provided her and her colleagues with forms to record the stock at the beginning and end of each journey and the takings at the end. At the beginning of the journey, 'Well, we have got sheets that tell us exactly what to do. So the stock, that's quite easy, it tells us it should be *x* amount ..., so we check that there is.' Then at the end of the journey,

> There are 2 sheets, one for food and one for drinks. Once the food has been done we can work out all the money for that. Like work it out how much 20 hamburgers would cost and that sort of thing. Put it on the sheet.

Eileen used an example of 36 cans of coke at the beginning of the journey, to explain to the Everyday Maths Group how they worked. 'So we just have to check there are 36 cans when we get on.' Then, at the end of the journey, 'We have to count, if there is only 6 (cans), then we work out we have sold 30. And they're 70 pence each and work out how much that should be.'

They totalled all their takings, 'At the end we have a total, then count all the cash, take out our £100 float and the amount of cash we've got should be the same in value as what we've sold.' How the money is totalled up is also prescribed by a form.

> We separate it into different denominations because our sheet says we have to fill in £20 notes, £10 notes, £5 notes, £1 notes. Scottish money has to go in separately from English. We have to count, separate all into English 10s, Scottish 10s, English 5s, Scottish 5s, pound notes, pound coins, fifties, twenties, 10s, 5s and the coppers together. We count each of them separately and write on the sheet how much we've got. Although we usually write it on a piece of paper first so we can fiddle round, so we've got the exact money to pay in.

These methods of stocktaking and reconciling the cash were prescribed by the company for which Eileen worked. So solving these problems became a matter of following the conventions of the company.

5.2.2.3 Using informal methods of problem-solving

In all the other problem-solving that I observed, or which was recounted to me, the participants used informal methods, not the formal methods traditionally taught in schools. They usually estimated rather than calculated and did not often use written forms of calculation in the situations I observed or they described. When they did use pen and paper, they did not usually use the formal algorithms taught in school. This accords with the findings of Lave (1988) and Nunes et al (1993): that people outside educational establishments tend to use informal methods that retain the meaning of the problem in hand. The informal methods the participants used were more likely to have been learned in everyday life than at school.

Although Eileen described one situation, when she was working on trains selling food, in which she used a school algorithm (Section 5.2.2.1), she mostly used informal methods of calculation. One of these was rounding up to the nearest pound, 'I know when I am adding things onto the price of a cup of coffee, I just round the coffee up to £1 and then take away one pence at the end, because it's 99 (pence) for a coffee and that sort of thing.' So Eileen did not use the traditional school algorithm for adding two prices. She used an informal method of adding on 1p to one price to make it a round number (£1), added the £1 to the price of the other item, and then subtracted the 1p she had added on from the total. Such informal methods of calculation have been documented by Lave (1988), Nunes et al (1993) and others, as part of everyday practices. They are now finding their way into educational practice (Heinemann Educational, 1991; BSA, 2001).

Eileen was describing an informal method of doing a simple closed calculation. Jean, on the other hand, explained her informal method of solving the much more complex, open problem of managing her personal finances. She told the Everyday Maths Group about her habits of managing her personal finances. She did not sit down and calculate her budget, 'I'm not money-minded, so I don't sort of count every sort of penny.' But she knew how much money approximately she needed for bills, 'rent, insurance, those things monthly. ... gas, electricity, telephone, three monthly.' And she had an intuitive feeling about how much she had spent and how much she had left.

> But I realise that I do have some sort of feel about where my bank balance is. ... It just happens I think, it's like with time, or cooking or anything, you just have a feel for it, you have a feel that somehow at the back of my mind I've paid *x* and *x* and *x* and the money must be running low.

Combining that knowledge with knowing when and how much she is paid, she would know if she had enough to pay a bill.

> Because you know if there is a bill, ... I tend to say, you know, towards the end of the month, I tend to say well, I can ease that over into the next month. ... Therefore I'll leave that bill until after I get paid on the 7th or whatever.

She would regulate her spending on non-essential items by knowing if she had been extravagant or frugal recently.

> Because if I do, I suppose if I do get terribly extravagant I tend to ease up, you know, over the next, sort of, two or three months. Say I've actually bought a lot of, well, things like clothes, I do like clothes, so I think hmm, hmm and ease up and you know try and sort of pay that off.

Jean's informal method of managing her money appeared to work for her, until the council she worked for moved her pay-date and upset her routine of earning and spending. I discuss this further in Section 5.3.2.3.

5.2.2.4 Idiosyncratic methods of problem-solving

Many of the informal methods that the participants used may have been learnt within communities of practice of which they were members. In other cases, often where the activity the participant was describing was situated at home, the construction of a problem and the finding of a solution appeared to be more idiosyncratic. In those cases, the community of practice in which the participant was situated may not have had a convention for resolving the particular kind of problem and the participant's feelings and identity were probably a strong influence on how they resolved the problem. For example, Ruth hated doing any kind of calculation, so she invented an ingenious method of labelling and organising her videotapes, so that she did not have to calculate the length of television programmes that she wanted to record and how much available tape she had.

> I just have a few tapes by the machine, which just get used over and over. They're the ones with these sliding things on them, ... a bit like Etch-a-Sketch, so you can write on them ... and then you just pull this tab across and it wipes it off.
>
> I always buy ... four-hour tapes, so that you know you've always got, well you've got two films on there basically. You know, you are pretty likely to be lucky. ... But also there's three, three or four (video-tapes). So if I've taped a film but I haven't watched it, I just take the tape out afterwards and put another one in that I know I can tape onto.
>
> It makes life so much easier if you have only got 4-hour tapes. ... You can get two films on it and quite often if it's late night, you know, there might be two, say, foreign films I want to watch one after the other, on Channel 4, for instance.
>
> So it's useful, it's an easily rememberable number, 4 hours. Therefore you know that you could tape a couple of half-hour programmes and still have room to tape something that you weren't expecting, or something. It gives you a bit of leeway.

Ruth's method of organising her videotapes was idiosyncratic, but resolved her problem of being able to record television programmes reliably, without having to do any calculations. Her horror of calculating led her to invent her own method. I address the influences of emotion and identity on problem-solving in Chapter 6.

My study confirms Lave's (1988) and Nunes' et al (1993) findings that in everyday life people tend to use informal methods of calculation that retain the meaning of the problem, although occasionally they use formal methods. The informal methods are very different from the methods of problem-solving traditionally taught in school. Sometimes the participants in my study followed conventions of the communities of practice of which they were members. At other times they invented their own idiosyncratic methods. I now consider another aspect of the socio-cultural contexts of the problem-solving in the study: the use of formal and informal tools.

5.2.5 The use of tools in problem-solving

Tools, or artefacts, are essential aspects of the socio-cultural contexts of problem-solving (Lave, 1988). Artefacts and conventions are one of Saxe's (1991) four parameters of culture and cognitive development. I am using the term 'tools' rather than 'artefacts', because I want to include things like environmental phenomena and human beings, which are not manufactured, but were exploited by the participants as tools to help them in their problem-solving. I identified a number of categories of tools in my data. The participants used tools which are manufactured to enable people to perform particular tasks of calculation, measurement and spatial orientation, like calculators, clocks and maps. I have termed these 'formal tools'. I include in this definition conventions like counting and standard calculation algorithms, which I see as abstract cognitive formal tools. But the participants often actively avoided using formal tools and used what I have termed 'informal tools' instead. These could be abstract cognitive, environmental, personal or social. In many cases the use of tools was conventional within the communities of practice in which the participants were acting. In other cases the participants created their own tools to deal with the particular problem that they were trying to solve. I shall now consider the use of formal tools, the active avoidance of formal tools, the use of informal tools, abstract cognitive, environmental, both concrete and non-concrete, personal and social, as well as the creation of tools.

5.2.5.1 Using formal tools

An important aspect of living in a technological society is the use of formal mathematical tools, both concrete and abstract cognitive. There were instances in the data when I observed, or the participants in the study described, using formal tools. For example, Joe had, amongst his gardening tools, a tape-measure, a ruler, a set square, and a calculator, each of which I saw him or his workers using on different occasions. Other formal concrete tools used in the study, were clocks, a diary, computers, a spreadsheet, a till, ATMs, cross-stitch patterns, printed instructions, printed forms, bank statements and maps. An example of using abstract cognitive tools was in Jean's and Rhiannon's discussion of trying to learn to dance by using the number system to count the rhythms of the music. Other examples were the use of the concepts of parallelism, rectilinearality, diagonality, symmetry, relative size and shape, the use of calculation algorithms for addition, subtraction and multiplication, and for the areas of triangles and quadrilaterals, and the use of the number system, the Imperial and metric systems of measurement, money systems and 12- and 24-hour clock systems for the measurement of time.

5.2.5.2 Avoidance of using formal tools in problem-solving

Much of the problem-solving I observed, or was told about, revealed an active avoidance of calculation and using formal mathematical tools and a preference for using informal tools. Although Lave (1988) and Nunes et al (1993) have documented the use of informal tools, they have not specified this active avoidance of formal tools..

Rhiannon said that when she was coming to my house for the first time, 'I didn't really have a very good map of the area in my mind and I didn't realise, for example, exactly where this place was.' But she did not look at the A-Z. She took a circuitous route based on familiar places. 'I got the bus from Reepham Road to Hadleigh Street, got the tube ... from Hadleigh Street to Chelmsford Park.' Then she tried to follow the directions I had given her.

> Then I remembered you telling me to come out of Chelmsford Park, I think you told me where the bus stop was. I couldn't really quite get to grips with that. When I came out I was a bit disoriented because it is on such a big junction, isn't there? So I had to fumble around asking people.

Rhiannon arrived at my house, so she successfully solved the problem of finding her way. Her avoidance of using a formal tool, the A-Z, meant that she did not travel by the most efficient route.

In Section 4.5.3, I referred to Cathy's avoidance of using a formal tool, a railway timetable. Her procedure for catching trains from Hadleigh to London was to catch the first train that came along.

> There's two trains going into central London. There's the fast train and the slow train, and I never know which it is going to be. I know there's a train every ten minutes or so. I have to allow for the fact that it's going to be the slow train which takes an extra 15 minutes. Quite often I might catch the fast one. I allow an hour to get into the centre of London and quite often I'm there half an hour early. But if I didn't plan that, I could be late.

So Cathy's method of getting to London at a certain time was to calculate what time she needed to leave Hadleigh, if she was travelling by slow train, and to arrive at the station at that time. Then she said, 'I should look at the timetable and work out when (the fast train) is, but that's a bit too organised.' She was displaying a reluctance to use a mathematical tool, the timetable, and to be 'organised', to behave in the most efficient way. She preferred to arrive at the station with enough time to get on whichever train came along and still be early enough for her appointments.

Other examples of the rejection of formal tools were Joe's, Ruth's and Jean's avoidance of using tape-measures, Mick's avoidance of using building plans, Claire's, Shelley's, Sheda's, Rhiannon's and Jean's avoidance of using clocks, Jean's and Rhiannon's avoidance of using standard algorithms for multiplying and dividing and Ruth's avoidance of anything to do with numbers, as far as possible. The participants chose not to calculate their money exactly, not to weigh or measure things using standard measures, and to estimate rather than calculate, in many of the situations they described, or that I observed. Instead, they employed strategies that did not require the use of formal tools, in many cases using informal tools instead, to resolve their everyday problems.

5.2.5.3 Using informal tools in problem-solving

The participants tended to use informal tools, as Lave (1988) found. By informal tools I mean phenomena in the situation, which are not manufactured tools, but which were used as tools by the participants in their problem-solving. I found that these informal tools fell into four main categories that have not been documented before. I have designated them abstract cognitive, environmental (both concrete and non-concrete), social and personal. Informal abstract cognitive tools consist of knowledge that can be added to problems, to assist in their resolution, but which are not formal abstract cognitive tools, like calculation algorithms. Informal environmental tools are phenomena in the situation of problems, which are not manufactured tools, but which are used for solving problems. Some informal environmental tools are concrete objects,. Others are non-concrete phenomena, such as the sun and shadows. Informal social tools are other people, who are used to assist in the solution of problems. Informal personal tools are aspects of the participant's body, which can be used to solve problems.

5.2.5.3.1 Informal abstract cognitive tools

Informal abstract cognitive tools, in the form of knowledge, can be added to problems to assist in their resolution. Examples of informal abstract cognitive tools are those Vera used when she had to calculate the number of hours she had worked in a building co-operative. One tool was midday, which she used as a staging post, to which and from which she could calculate. Another tool was her knowledge that the interval between 9.20 am and 4.20 pm is the same as the interval between 9 am and 4 pm.

> Well, say I started work at say 9.20 and went to 4.20 ... They're both twenty past so it might as well be: nine to twelve is three and twelve to four is four. ... That would be seven hours, minus an hour for lunch is six hours.

These informal abstract cognitive tools enabled Vera to do these calculations in her head, instead of using a pencil and paper and employing a school algorithm.

Eileen used informal abstract cognitive tools most of the time, to calculate combinations of food prices, when she was working on the train, such as adding 99p for coffee to the price of another item, by adding £1 and subtracting 1p, (described in Section 5.2.2.2). She also said she could picture calculations in her head, as if she were using a calculator: she mentally put in the numbers and the answer flashed up, for example the cost of twenty bags of crisps at 55p each. Eileen also said that she visualised diary pages, to keep track of her appointments. Rhiannon used a radio to time her cleaning work. She knew that when particular programmes came on, she should be doing particular tasks, in order to get through all the work, in the time for which she was being paid.

5.2.5.3.2 Informal environmental tools

Informal environmental tools are phenomena in the situation of the problem, which can be used in the resolution of the problem. An example recounted in the study was the measurement of time by assessing the sizes of shadows, for the Moslem practice of prayer. Shelley explained to the Everyday Maths Group that the religious requirement is to say five prayers a day, timed by the position of the sun, not the clock: 'One at sunrise, one at sunset, other one at lunch-time, one in between lunch and sunset, and one at night before you go to bed'. There is a strong imperative to keep to the correct times. Shelley said,

> There's one condition of prayer: that you should keep the time, very strict. People who practise prayer properly follow this. ... I've seen in my village 30, 40 years ago, ... the time you can work out from your own shadow. After twelve, your shadow will be longer and longer and longer until the sunset.

So the sizes of shadows were used as informal environmental tools to solve the problems of finding the correct times to pray.

Some informal environmental tools are concrete. Rhiannon used landmarks to find her way without using a map. She said that if she were in an unfamiliar place, she could go for a walk and then find her way back, by a feeling for where she was, but also by spotting landmarks and noticing how things in the landscape looked.

Claire also used a landmark as an environmental tool, in combination with the formal abstract cognitive tool of odd and even numbers, when she wanted to estimate how many lengths she had swum in the swimming pool. By noticing at which end of the pool she had arrived, she knew she had completed an odd or even number of lengths, which helped her to remember which number she had reached.

The upholsterers and gardeners often used the materials with which they were working as informal tools to measure their appropriate size and orientation and to fit them onto objects or into specified spaces. The workers matched, measured or cut one material against another, without using standard measures or calculation. These processes enabled them to fit one shape or series of shapes onto or into another by cutting, stretching and compressing, taking into account the physical properties of the materials, so that, for example, turfs would grow into a smooth lawn and the chair seats would be caned in a traditional pattern. Underlying what they were doing was an understanding of the concepts of relative size and shape, not in the abstract, but inherent in the gardening and upholstery materials and processes.

Lee, one of Joe's gardeners, told me that the important thing about laying a lawn is that it is not allowed to dry out in the first few weeks when the roots are developing. He said that gardeners always lay the lawn as the last task in a garden, so that it is walked on as little as possible. They leave the customer the task of keeping the lawn watered, if the weather is dry. Customers do not always do this adequately. If the lawn dries out, the turfs shrink and holes are liable to appear where the turfs join. Therefore it is very important to lay the lawn in such a way that the turf is not stretched, that there are as few joins as possible, especially round the edges, and that no small pieces of turf are used (Fig. 5.3).

At the top of the Yew Tree Road garden, where the side edges of the lawn were not going to be parallel to the side fences, Lee had cut off the turfs parallel to the fence in a stepped pattern (Fig. 5.3.4). He finished the lawn by laying a strip of turfs down each side. These edging strips of turf ensured that there was the minimum number of joins at or near the edges of the lawn. Where he had cut the turfs in a stepped pattern, he laid the side strips over the edges, and cut off the 'steps' along the edge of the side strip, using the strip as a guide for cutting (Fig. 5.3.5). The use of one turf as a guide for cutting others, as an informal concrete tool, ensured that he got a very snug fit between the edging turf and the other turfs.

Another example of an informal concrete tool was the configuration of holes drilled into the frame of a chair that Alice was re-caning, in the upholstery class. This configuration of holes helped Alice to place the canes correctly to create the traditional pattern. She explained to me how she had done the re-caning (Fig. 5.4). She had laid canes at right angles to the back of the chair, parallel to it and diagonally across the chair, anchoring the canes in the holes in the chair frame (Figs. 5.4.1, 5.4.2, 5.4.3, 5.4.4). The pattern Alice had made with the canes resulted in a series of octagonal spaces between the canes in the seat of the chair (Fig. 5.4.6). Alice would have been able to check that the canes were correctly orientated, by looking at the pattern they were making. She did not have to measure the 90^0, 45^0 and 135^0 angles, or think about the angles as numbers: the placement of holes in the chair frame and the procedure she followed, meant that she was able to check visually that the canes were at the required angle.

In these two latter examples of the use of informal concrete tools, the workers started with something that needed working on, a piece of ground or a chair frame, which has spatial properties: size, shape, a configuration of holes. They used materials, turfs and canes, with size and shape and other physical properties, like flexibility, strength, stretchability or compressibility. When they were working, they matched the materials against each other, or against the space or the object on which they were working: they used the materials, objects or spaces as informal concrete tools for measurement.

5.2.5.3.3 Informal personal tools

Informal personal tools are aspects of the participant's body, which can be used to solve problems. There were several examples in the data of people using their bodies as informal personal tools for measurement. When Joe was measuring up for a new lawn, he said that he preferred to use the traditional (Imperial) system of measurement, because it is based on the human body. He said his half-thumb is an inch, his feet are about one foot long and his pace is about a yard. It is a yard from his fingers to his nose, and he knows to where a yard from the ground comes on his body. When he was estimating the cost of a job, I observed him measuring with his body: pacing out the ground to estimate the dimensions of the garden. Other examples of the participants using their bodies as tools are Shelley and Sheda measuring cloth in the markets of Bangladesh and Somalia and Jean measuring the heights she wanted her kitchen units to be, on her body.

5.2.5.3.4 Informal social tools

There were many examples in the data of the participants using other people as tools to solve everyday problems. I reported in Section 5.2.5.3.2 that Shelley described using her own shadow, to work out the time for prayer. Sheda's father used her shadow as a tool to tell the time. She said 'I can remember when I was young, my father telling me to stand outside. To say his prayer, he will know when it's the noon. At noon the shadow is around you. It's not tall, it's compressed like that.' She indicated the small size with her hands.

Joe deployed his workers on the various tasks in the gardens, for example Mick did the hard landscaping and Lee laid the lawn in the Yew Tree Road garden. They were tools that Joe used to get more work done than he could do alone.

Rhiannon used people in the street and the bus driver to help her find her way to my house, (reported in Section 5.2.5.2). She tried looking at a map and then resorted to getting help from other people. '... So eventually someone told me and I asked the driver to tell me when I got to Ipswich Road. ... He dropped me off right at the end of the road, so I had to walk all the way back, back here again.' Claire was helped by other people, when she nearly missed a plane. The taxi driver phoned the airline staff, who allowed her onto the plane with her luggage in the cabin, at the last moment. Sheda asked people in shops what the time was, when she had a hospital appointment and she had lost her watch.

5.2.5.3.5 Creating tools

Some informal tools belong to particular communities of practice, like using shadows as tools to tell the time for Muslim prayer, or using the body to measure in gardening. In other cases the participants appeared to have created their own idiosyncratic tools to suit their own purposes (Lave, 1988).

Rhiannon created a tool to solve a problem she identified in an examination. She wanted to calculate how much time, out of a total of three hours, she had to spend on each of four questions.

> I drew a circle to represent a clock-face at the top of the page. I kind of imagined 40 minutes for each question, first of all. Then I traced from the top, the 12 o'clock point, to 40 minutes, and made a mark for one. Then let's see, another 40 minutes would be 20 past, so I made another mark. Then another 40 minutes would be up to the hour. So that's two hours for three questions. Another hour for the other, so that was wrong. It was this kind of not very exact testing out of how much time.

There were several other examples of the participants creating their own tools. Jean pinned all of each of her client's shopping receipts onto large sheets of paper to make visual representations of what they had spent. She said that she did this so that she could understand it as well as her clients. Eleanor created an heuristic of one overhead projector transparency every two minutes, when she was planning the presentation of an academic paper. She used this heuristic flexibly, as some transparencies needed more explanation than others. Ruth's manager at the sports centre used a pool of change that she kept in a drawer to reconcile the cash in the till with the computer record. Similarly, Eileen and her colleagues on the train kept their takings and tips together. They gave the company cashier what they had calculated the takings should be from the stock records and divided the remainder of the cash between themselves as tips. Again similarly, Jean threw her clients' change into the bottom of her handbag, while she was out shopping with them. When she had calculated what they had spent, she paid them what they should have had left, out of her own money.

In this section, I have discussed the use of tools to solve everyday problems by the participants in my study. I have categorised them as formal and informal and shown that there were many instances of the active avoidance of using formal tools. I have categorised the informal tools that were used as abstract cognitive, environmental, both concrete and non-concrete, personal and social. I have also described how the participants often created their own idiosyncratic informal tools to enable them to solve everyday problems. I now turn to whether the participants considered the solutions that they found to problems were satisfactory or not.

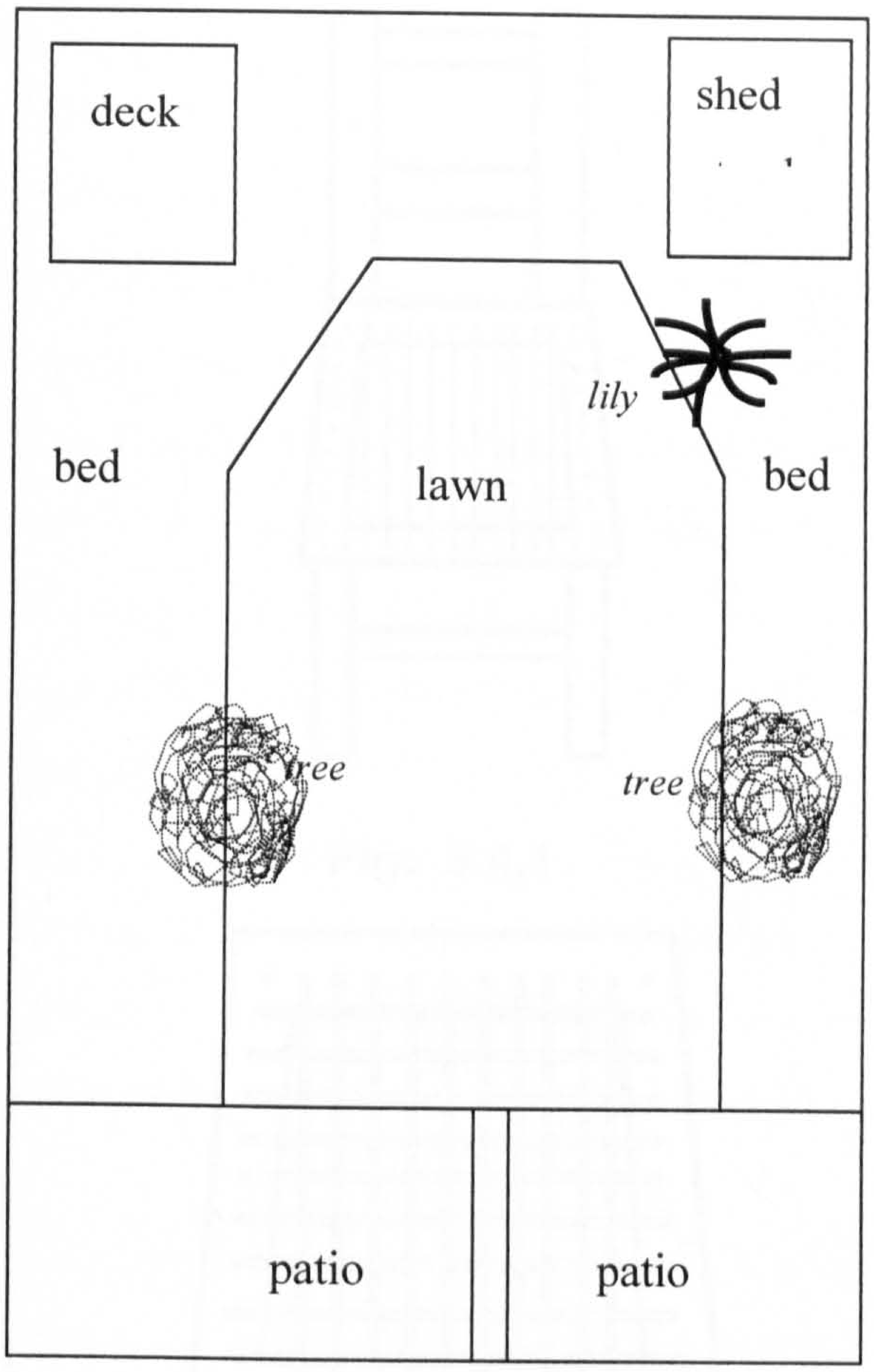
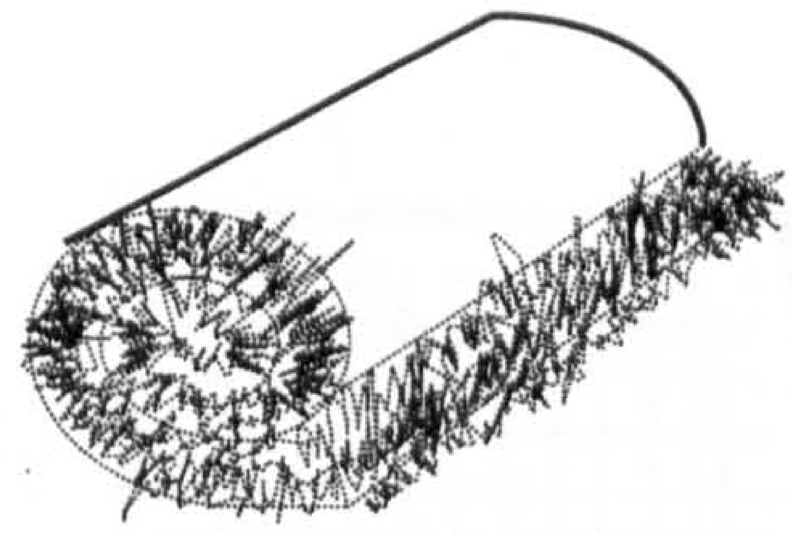


Fig. 5.3.1 Plan of the second garden

Fig. 5.3.2 Turf: 0.33m x 3m.



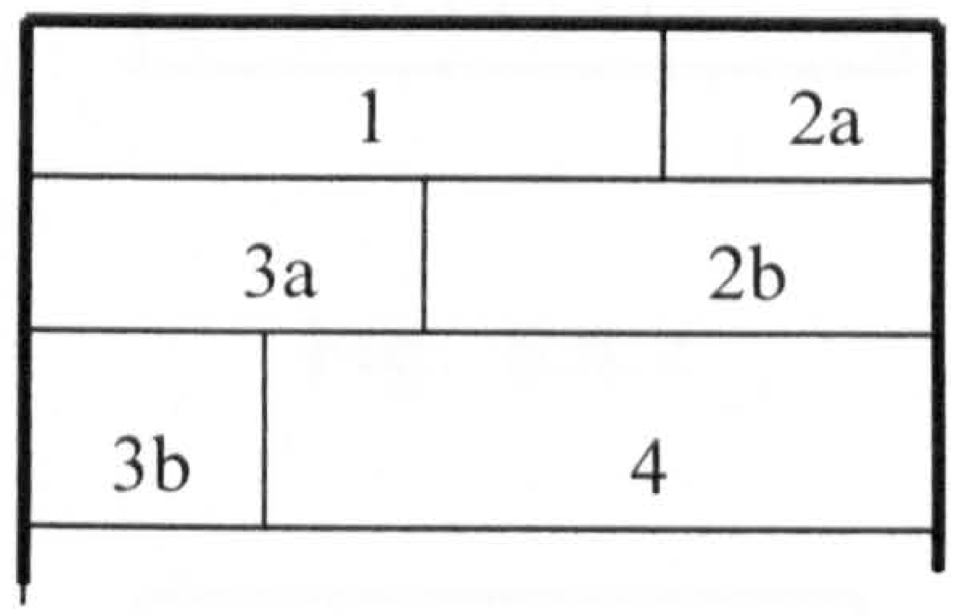


Fig. 5.3.3 Order of laying the turfs

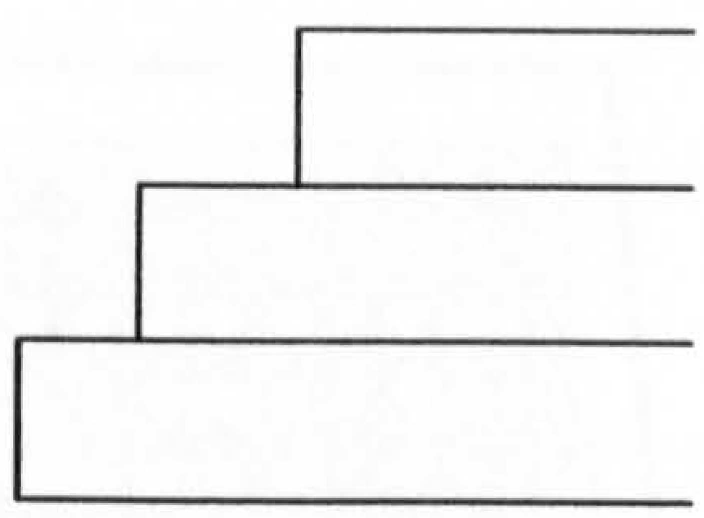


Fig. 5.3.4 Stepped edges of the turfs

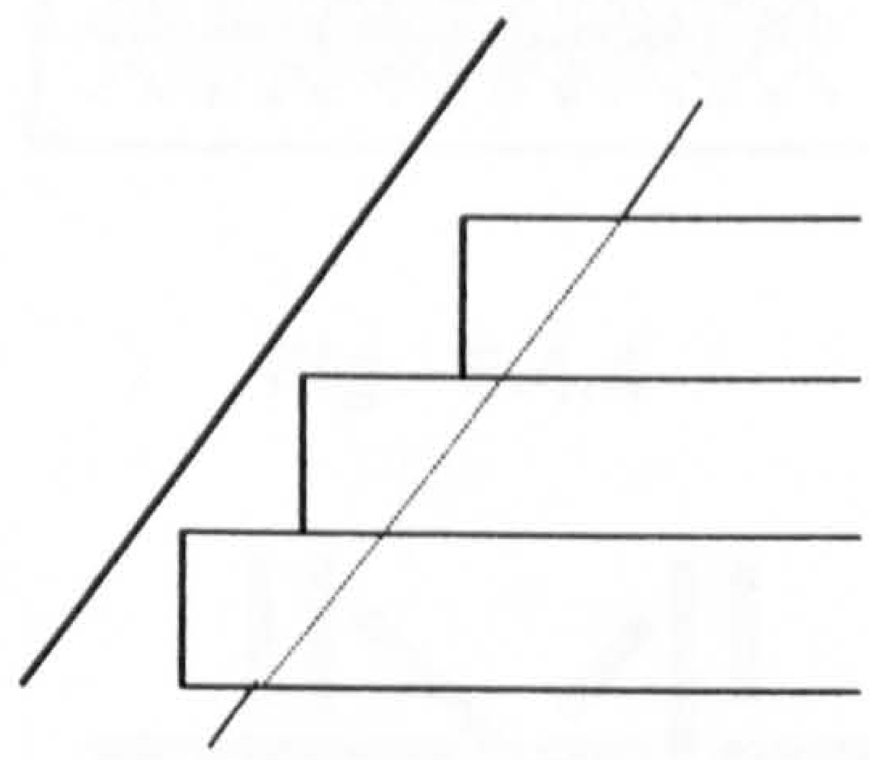


Fig. 5.3.5 Laying the edge of the lawn

Fig. 5.3 Laying the lawn at the Yew Tree Road garden

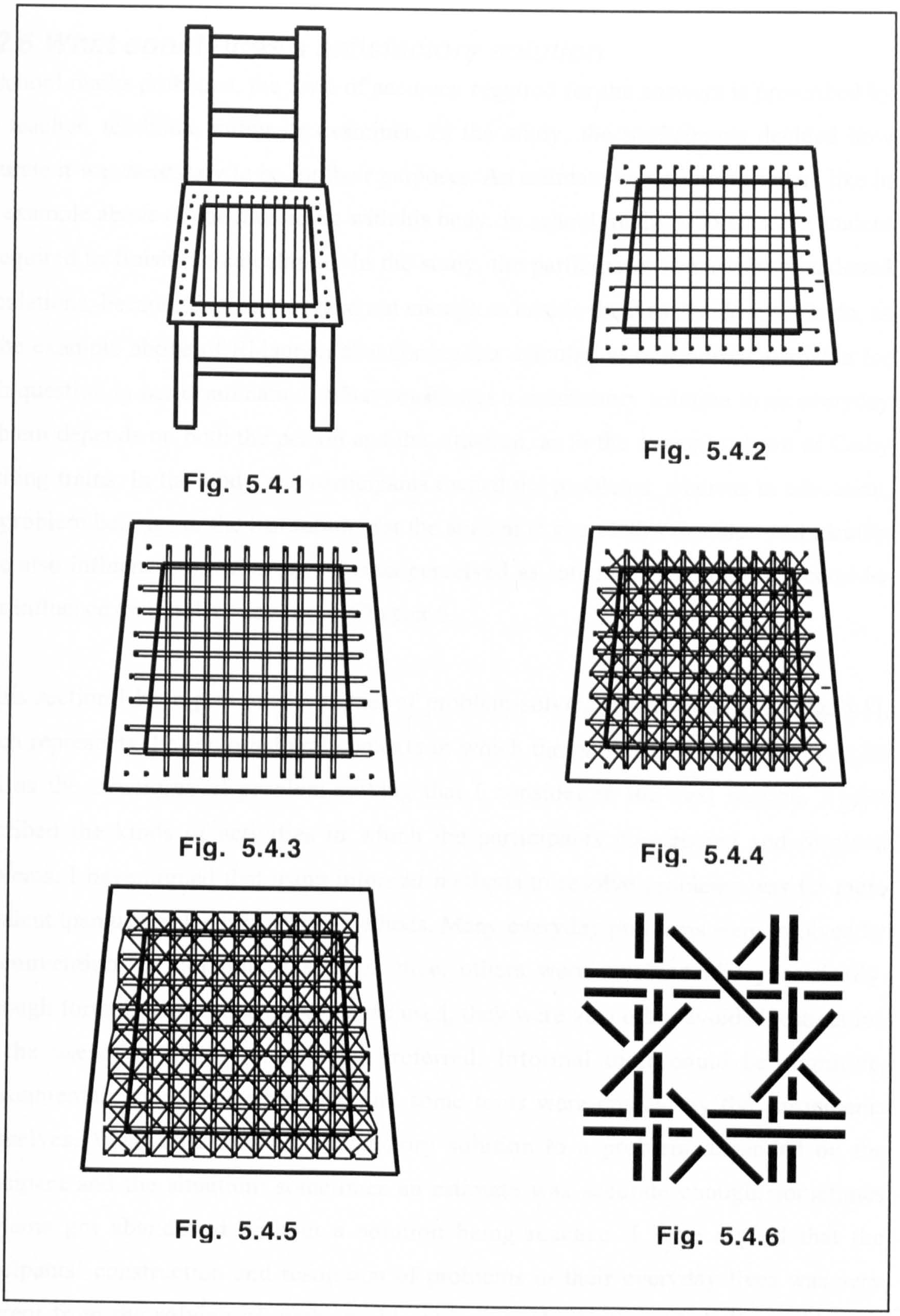


Fig. 5.4 Caning the seat of a chair

5.2.6 What constitutes a satisfactory solution

In school maths problems, the level of accuracy required for the answers is prescribed by the teacher, textbook author or examiner. In the study, the participants decided how accurate it was necessary to be for their purposes. An estimate was often sufficient, like in the example above of Joe measuring with his body. In school maths problems, the student is required to finish the calculation. In the study, the participants sometimes abandoned calculations, because they had worked out enough to enable them to decide what to do, as in the example above of Rhiannon abandoning her calculation of the time available for each question in her examination. What constitutes a satisfactory solution to an everyday problem depends on both the person and the situation, as in the example above of Cathy catching trains. In the study, the participants owned the problems, whereas in education, the problem belongs to the institution, not the student (Lave 1988). Emotion and identity were also influences on what participants perceived as satisfactory solutions. I consider their influence on problem-solving in Chapter 6.

In this section I have presented a model of problem-solving in everyday life (Fig. 5.1), which represents the socio-cultural contexts in which the participants were involved, as well as the structures of problem-solving that I consider in the next section. I have described the kinds of activities in which the participants constructed and resolved problems. I have argued that using informal methods to resolve problems was far more prevalent than using standard school methods. Many everyday problems were resolved by the conventions of communities of practice, others were resolved idiosyncratically. Although formal mathematical tools were used, they were also often avoided, estimation and the use of informal tools being preferred. Informal tools could be cognitive, environmental, concrete, or personal and some tools were created by the participants themselves. What constituted a satisfactory solution to a problem depended on the participant and the situation: sometimes an estimate was accurate enough, sometimes problems got abandoned without a solution being reached. I have argued that the participants' construction and resolution of problems in their everyday lives was very different from the solving of maths problems in school situations. I shall consider the implications of the study for maths education in more detail in Chapter 7. I now turn to the second aspect of problem-solving in everyday life which is represented by my model (Fig.

5.1): the structures of everyday problems and their solutions.

5.3 The structures of everyday problems and their solutions and their differences from school maths problems

In this section, addressing my second research question (see Section 2.6), I consider the structures of everyday quantitative and spatial problems and their solutions that I found in the data. I found different levels of complexity of problems and a four-stage cyclical logical process of problem-solving, which is represented in the model of problem-solving in everyday life (Fig. 5.1). I argue that there are differences between the structures of everyday problems and school maths problems.

5.3.1 The levels of complexity of everyday problems

In this section, I discuss the levels of complexity of everyday problems and their solutions in the data. I have designated some of the problems that the participants constructed and resolved as simple, by which I mean that they have a small number of variables and could be solved by one or two successive calculations or decisions. I have designated other problems as complex, by which I mean that they have many variables. In some cases, some of the variables are qualitative, not quantitative. They therefore have to be weighted, in order to able to compare them with the quantitative variables, before finding a solution to a problem (Lave, 1988). I have designated a further category of problems as compound, meaning that they contained a number of contributory problems, which had to be resolved before the compound problems could be solved. In addition, I describe some problems as closed, in that they have only one possible appropriate answer, and others as open, in that they have a range of possible appropriate answers. The more complex a problem was, the greater number of variables, the number that were qualitative, or the greater the number of contributory problems it had, the more likely it was to be an open question, with many possible appropriate answers.

5.3.1.1 Simple, closed problems

Some of the problems that the participants constructed and resolved were simple: they had a small number of variables and could be solved by one or two successive decisions or calculations. Simple problems tended to be closed: there was only one appropriate answer to each question. An example in the data of a simple, closed problem is one about calculating time, that Eleanor described to the Everyday Maths Group.

> I am adding it up. So if I get up at half past seven and I know it takes me an hour to get ready then I will add that up so that will be eight thirty. Then I'll know that it takes me forty minutes to get to work, so I'll try to add 40 minutes onto half past eight, like that.

This kind of problem is like traditional school maths problems in that it has only two successive calculations, there is only one variable, time, which is quantitative, not qualitative, and there is only one appropriate answer. It is very similar to the following school maths problem:

3. A train journey lasts 4 hrs 20 min.
   We leave the station at 12. 15, what time should we arrive?
   In fact there is a delay of 25 mins.
   When do we actually arrive? (Coben and Black, 1984, Book 4, p 36.)

Eleanor's problem is unlike school maths problems in that the problem is not actually stated. 'What time will I get to work?' is implied, not stated, an example of indexicality (Garfinkel, 1968). Although a few of the problems in the study were simple and closed like this one, most were not.

5.3.1.2 Complex problems

Many of the problems recounted in the study were complex, in that they had many variables, some of which were qualitative and had to be weighed against quantitative variables. An example of a problem with many variables, some qualitative, is one Cathy described to the Everyday Maths Group about how she made plans about buying books for the further education college library where she worked. The book suppliers sent the library slips of paper describing available books and the librarians selected what they wanted to purchase from these. Cathy used qualitative criteria for selecting books. She considered the titles, the publishers' descriptions and the subject matter in relation to the syllabuses of the courses running in the college, and whether the book was a text book or would be good background reading for a particular course. She took into account the readership level: whether the book was aimed at further education students. If the library already had the book and the booksellers were offering a new edition, she investigated whether the text had been updated. If teachers had requested the book, she took that into account. She investigated the binding of the book: the library rarely bought hardback editions of books.

Cathy also used quantitative criteria, some of which were precise. She found out how many books on the particular subject the library already had and the number of copies of the specific book they had in stock. The library only stocked five copies of any textbook, because the students were supposed to buy their own copies. She took into account the number of times a book had been borrowed, by consulting the computerised records or looking at the date label in the front of the book. She considered the price: the library rarely spent more than £25 on a book.

There were also less precise quantitative data that Cathy took into account. There was room for 22,000 books in the library and the library budget for each course was loosely based on student numbers. But the quantity of books required for different subjects varied.

> It's up to me to work out exactly how much I spend on each of those different courses. And I should really go for student numbers on that, but I didn't really last year because in fact there's not very many history students for example. ... History is one where you need a lot of background reading, so they need more books.

Some subjects needed updating more frequently. For example, Cathy said that computer science books went out of date very quickly and had to be replaced frequently. The use students made of the library varied between courses, for example the music course had its own collection of books and its students tended not to use the college library.

With so many variables to take into account, the decisions Cathy had to make were complex. She had to use both qualitative and quantitative criteria to choose which books to purchase, so that the resolution of the problem could not be achieved simply by calculation. There were many possible answers to Cathy's problem: it is an open problem. I shall discuss how Cathy made decisions about the purchase of books in Section 6.3.3.

5.3.1.3 Compound problems

I have designated some of the problems in the study as compound: they contained contributory problems, which had to be resolved first. The participants did not necessarily have fully developed overall plans for finding a solution, when they identified a compound problem. In some cases, they may not have been aware of all the contributory problems at that stage. They may have identified one or more contributory problems that needed to be resolved first, before proceeding to make further plans for solving other contributory problems which had emerged, before resolving the overall problem.

Joe, the gardener's, makeover of the large garden in Yew Tree Road is an example of a compound problem with many contributory problems, some of which had to be addressed several times (Fig. 5.3). The job involved building two adjacent patios, on different levels, with steps to the house and the garden, building a stand for a shed and a sun-deck at the bottom of the garden, replacing the fence all round the garden, extending the width of one flower-bed and reducing the other, weeding and re-planting the flower beds, pruning the shrubs and replacing the lawn. I am considering each of these tasks as contributory problems.

Joe had to plan the work to fit the agreed price of £5000. He had to estimate the materials and plants that were needed, and he had to plan the physical work for himself and his two employees, Ben and Gerry. He decided to sub-contract the construction work on the patios and shed-stand to Mick, a builder, who gave him an estimate of £950. Although he did not do the physical work of construction himself, Joe had to make sure it was done properly.

So far Joe was following a path of habitual everyday problem-solving. Although the problems were particular to this garden, they were all familiar problems. Then things went wrong with the construction work. Mick did not build retaining walls between the patios and the garden. Because the garden was on a slope, this meant that water would drain onto the patios from the garden and make them wet. He under-estimated the number of patio stones required for the job as 90 instead of the 120 he eventually used. Mick also built the wall between the patios on top of the patio stones, instead of making footings for the wall under the ground. Mick built the step to the house so that it covered the damp-proof course. This would enable damp to rise up the wall of the house. He put a drainage pipe to drain water from the garden onto the patio, which would make the patio wet. He did not finish properly round the drain hole for the down-pipe on the house, so that the house would get wet. The drainage hole on the upper patio was wrongly positioned so that one corner of the patio would collect water.

So Joe now had seven more contributory problems, which had not existed at the beginning of his work on the garden, but were consequences of his solution to the problem of constructing the patios: employing a sub-contractor. Joe insisted that Mick put all his mistakes right, but this solution left him with two other contributory problems. As Mick did not have his own transport, Joe had to spend time going to fetch the extra materials. He also ended up paying Mick £1600, instead of the estimated £950, because, he said, Mick had become very abusive and Joe was fed up with arguing. As he had agreed a fixed price for doing the whole garden, Joe had to try to absorb the extra £650, so that he could still make a profit on the whole job. He appeared to do this by sending some of the workers off to do other small jobs, or going off himself, when they were waiting for deliveries of materials or turf, or could not all work in this garden for some other reason (see Section 5.3.2.1). He also employed Lee, who was an experienced gardener and who had worked for him before, on a temporary basis, to help him finish the garden more quickly.

This example shows how one compound problem, to make over a garden, was made up of several contributory problems, which in turn had more contributory sub-problems. Moreover, during the course of solving these contributory problems, other contributory problems emerged from the partial solutions. These had to be solved before the original compound problem could be solved: to complete the makeover of the garden. This example also illustrates the open-ended nature of many of the everyday problems in the study: there was not only one solution to each problem, but a range of possible solutions.

Such compound problems are very unlike traditional school maths problems, which never have so many contributory problems, never have qualitative variables and usually have only one appropriate answer. An example of such a problem, taken from a diagnostic test used in a college of further education, is in Fig 5.5 (City and East London College, 1991). In this question, 720 books sold by a bookshop are categorised according to their contents, fiction or non-fiction, and their bindings, paperback or hardback. The resulting four categories of books are represented by a pie-chart. The student is asked to calculate the number of books in two of the categories. What the question is designed to test is the candidate's ability to extract information from a pie-chart, demonstrating that the candidate has this underlying knowledge. The context of the question, books and a book-

77. A bookshop sells 720 books in a certain week. The books are divided into the following categories:

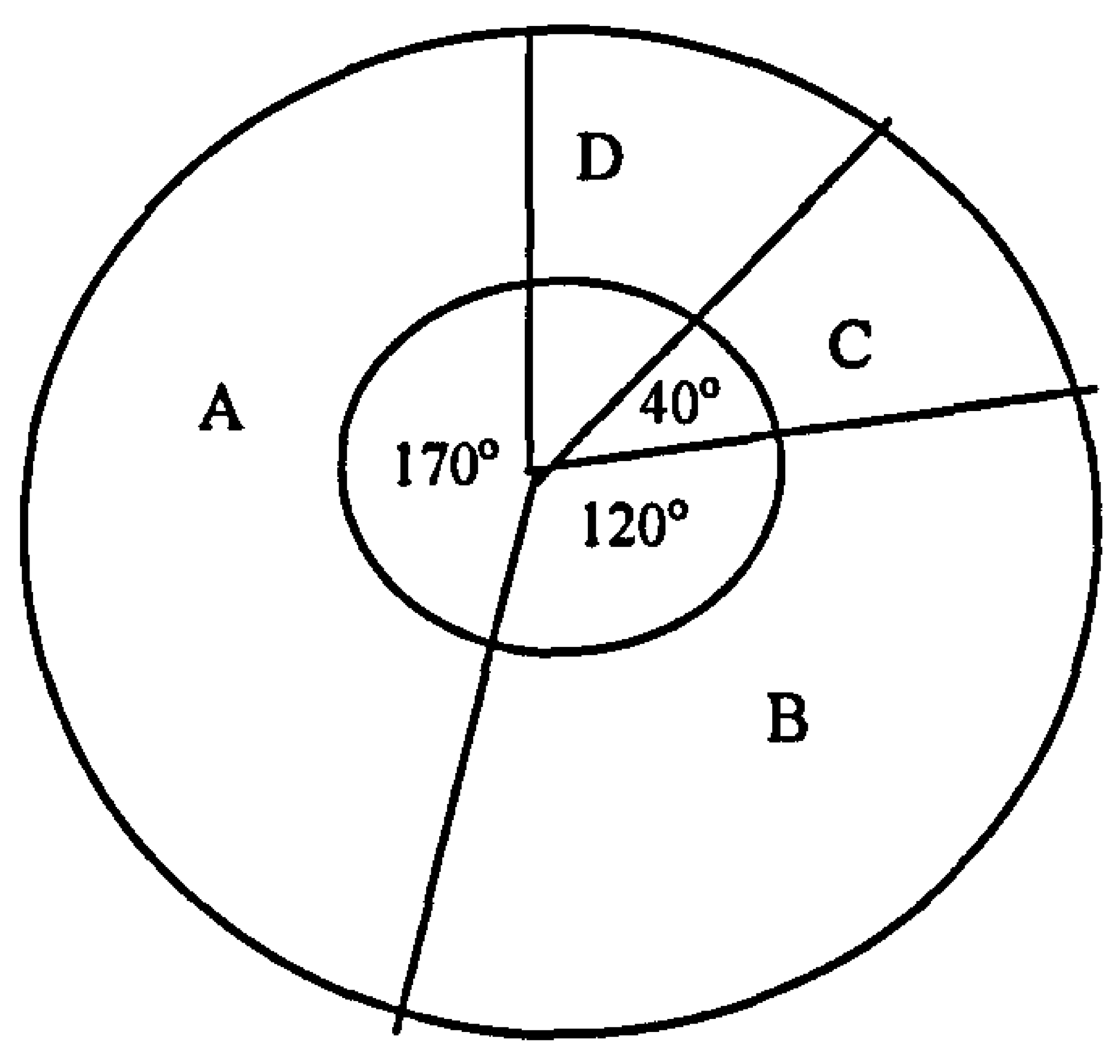
A Paperback fiction

B Paperback non-fiction

C Hardback fiction

D Hardback non-fiction.

These categories are expressed by the following pie-chart:



a) Calculate the number of books in category A.

b) Calculate the number of books in category D.

Fig. 5.5. School maths problem. (City and East London College, 1991)

shop, are artificially constructed to give the problem meaning, although I question whether it would be of much interest to anyone who did not work in a bookshop or a library. But, in any case, it bears very little relation to reality, as Cathy's story makes clear (Section 5.3.1.2): there are more categories of books than their bindings and whether they are fiction or non-fiction. The problem does not explain why these four categories are significant, and others, like price, are not, or why a pie-chart is an appropriate representation of them. As in most traditional school maths problems, no purpose is given for the representation or the calculation. This is a compound problem, because the answers to each of the questions have to be calculated in three steps. For the first question, this requires recognising that the 360^0 represents 720 books, deducing that each degree of the circle represents two books (a nice round number) and therefore that 170^0 represents 340 books.

In this section, I have contributed to answering my second research question (see Section 5.1). I argued that, although a few of the everyday problems that the participants in my study constructed and resolved were simple, many were complex, having many variables, some of which were qualitative. Many of the problems were open: they had more than one appropriate solution. Problems could also be compound: they could have many contributory problems, which have to be resolved first. I have also argued that the quantitative and spatial problems in the study were very different from problems traditionally used in maths education, which tend to be simple, to have only a few variables, none of which are qualitative, and to be closed, having only one prescribed answer.

5.3.2 The cyclical logical structures of everyday problem-solving

In this section, I continue to address my second research question (see Section 5.1), considering further the structures of everyday problems and their solutions. The problems the participants constructed and resolved had a common four stage logical structure: the identification or construction of a problem; planning how to set about resolving the problem; executing the plan; and reviewing progress in solving the problem. The centre of the model that I discussed in Section 5.2 (Fig. 5.1) represents this four-stage structure and the different routes that the participants took round it in resolving problems with different structures.

The centre of the model is similar to Gal's (1999) interpretation of the 'management of numerate behaviour' (p 10). Gal's analysis does not specify the identification of a problem. His identification and choice of 'one of several courses of action' (1999, p 10) is similar to my second stage of 'planning what to do'. His 'execute the chosen plan' and 'monitor progress' (Ibid, p 10) are similar to my 'executing the plan' and 'reviewing progress' (Fig. 5.1). My model (Fig. 5.1) also has similarities with the constructivist cycle described by Millroy (1992), after Confrey (1991), with the narrower focus of solving maths problems in educational settings. This has a stage, called the 'problematic' (Millroy, 1992, p 26), similar to my first stage, 'identifying problems' (Fig. 5.1). Confrey's constructivist cycle does not have a planning stage similar to my second stage, the problem-solver moves directly from the 'problematic' to 'action' (Millroy, 1992, p 26), the latter being similar to my 'executing the plan'. Confrey's third stage 'reflection' (*Ibid*, p 26) is similar to my 'reviewing progress'. Polya (1973) and Marr and Helm (2002) recommend that students learn to apply a four-stage of process of problem-solving. Polya's four stages are 'Understanding the problem', 'Devising the plan', 'Carrying out the plan' and 'Looking back' ('Examine the solution obtained') (1973, pp xvi and xvii). Each stage has a number of alternative suggestions., making it a complex model. Marr et al (2002) call their process the 'Task Process Cycle'. The four stages are 'select relevant information', 'choose strategy', 'apply strategy' and 'reflect on outcomes', (p 186). Although Gal's, Confrey's, Polya's and Marr's models differ from mine in detail, all four embody the underlying idea that problem-solving is a cyclical process: that a first attempt may not be successful and may therefore need to be modified and repeated. My model is also much more complex than Gal's, Confrey's, or Marr's: the arrows represent different routes that the participants took in resolving problems with different structures. I explicate these different routes below.

I have used the term 'logical' to describe the structure of problem-solving because following this four-stage process requires an understanding of cause and effect: 'If I do this, then this will happen', and its corollaries, 'If I want this to happen, then I must do this', and 'This has happened because of that' (Cheng and Holyoak in Nunes et al, 1993). Planning involves thinking about the conditions required for desired results, for example, in working out the time to leave home to catch a plane: *if* I want to catch a certain plane, *then* I must leave home by a certain time.

I was surprised to find these logical structures in the participants' accounts. I had thought, before undertaking the research, that non-mathematicians would think in different ways to mathematicians, that they would resolve problems from their experiences of similar problems, and would not tackle new types of problems in a logical way. I did not know how they would do this: that was what I was trying to find out. Like Luria (1979), who found that uneducated peasants could not categorise objects according to his schema or deduce the conclusions of syllogisms with unfamiliar content, I thought that non-mathematicians found logical reasoning difficult. This was partly based on my experience of teaching maths to adults: many seemed to find great difficulty in constructing a logical progression of calculations from a school maths problem. However, the analysis of my data showed me that my premise was false: the participants' construction and resolution of everyday problems clearly showed logical structures.

My first analysis was of the data from the Everyday Maths Group, where I was collecting the participants' accounts of their past experiences, rather than the experiences themselves. The question arose of whether the logical structures might be part of the reconstruction of past experiences, which happened during the formulation of the experiences into the accounts. In telling stories about what had happened to them, did the participants unconsciously make them fit a logical framework that is part of our culture, the way we give accounts of ourselves? I was therefore cautious about assigning the logical structure to the participants' construction and solving of problems, and only saying that it appeared in their retrospective accounts. However, my second analysis was of the fieldnotes from my observations of and conversations with the upholsterers and gardeners. These contained my direct observation of the construction and solution of problems, as well as *post hoc* accounts of problem construction and solution. On analysis, the directly observed incidents of constructing and solving problems revealed the same logical structure, as the *post hoc* accounts.

However, the accounts of problem construction and resolution did not have syllogistic forms. They were not described in the same precise and concise formal way that traditional school maths problems are expressed. The participants used everyday language and described the context as well as the construction of the quantitative or spatial problem and its resolution. They did not always give their accounts in the historical order in which they had acted. Sometimes they described the resolutions, before identifying the problems and their plans for resolving them. Sometimes the participants recounted a contributory problem before describing the compound problem of which it was part. They did not always spell out the four stages of problem-solving. Sometimes these were implied, a form of indexicality (Garfinkel, 1968): the narrator assumed that I would know what they were talking about.

It is also important for adult numeracy and school mathematics teachers and teacher educators, textbook writers, examination and test question writers to recognise that people without a good mathematical education do produce logical accounts of their activities, even though these accounts are not in the form of syllogisms or traditional maths problems.

> Acknowledging development and use of mathematical reasoning by people with limited school experience is a crucial step towards promoting opportunities for progress and learning in schools. It is by bringing previous knowledge into the process of understanding new situations and representational systems that students develop more advanced mathematical knowledge (Schliemann, 1999).

5.3.2.1 Solving simple and complex problems

The model (Fig. 5.1) represents the resolution of problems, where first, a problem was identified and second, the participant made a plan of how to resolve the problem. In the simplest situations, the participants went on to execute their plans and then review whether the problems were satisfactorily solved. But sometimes participants experienced difficulty with making satisfactory plans and had to return to the identification of the problem to reformulate it, and then back to the planning stage to produce the new plan of the solution.

An example of this is when Joe sent Ben and Gerry across Yew Tree Road to another house, where the owners had asked Joe to prune their wisteria, while the gardeners were waiting for the turf to be delivered. This small problem, about pruning wisteria, was part of a much more complex quantitative problem that Joe had, of trying to re-coup some of the outgoings, in this case Ben's and Gerry's wages, while finishing the makeover of the

Yew Tree Road garden. I described this in more detail in Section 5.3.1.3. Ben and Gerry came back a few minutes later, saying that they thought there might be two wisteria plants and they were not sure how to proceed. Joe had to go over and have a look at it. So Joe's plan, of having his workers get on with a job without his supervision, while he did something else, had to be modified.

5.3.2.2 Solving compound problems

In some cases, the participant realised at the planning stage of the logical process that, in order to resolve the original compound problem, one or more contributory problems needed to be resolved first. Each of these contributory problems had to be identified, a solution planned, the plan carried out and the progress reviewed. So she or he had to move from the planning stage to the identifying problems stage. But sometimes the participant did not realise, when formulating her or his plan, that there were contributory problems: these did not become apparent until she or he was trying to execute her or his plan. Or the contributory problems did not become apparent until the participant had reached the stage of reviewing progress, when she or he would have to move to the identification of the contributory problem.

I describe an example from the data where the participant set out to resolve one problem, but, during the process of solving it, had to resolve several contributory problems and where she reviewed and reformulated these contributory problems and the compound problem several times before she achieved a solution. I represent part of the construction and resolution of this compound problem in Fig. 5.6. Sheda gave an account of how she had got herself to the Everyday Maths Group that morning. She identified two contributory problems that she needed to resolve before coming to the group: getting up and feeding her son. She made a plan, 'Last night I said, "OK, I have to get up at 8 o'clock", because my son, who is a year old, gets up at 8 o'clock. I allocated an hour for his feed. "I will finish feeding him at 9 o'clock."' A second contributory problem was to get herself ready, so she made a plan for this, '"Then maybe an hour will be enough for me to get ready."' This would give her time to get to the group by 11 o'clock.

But things did not go according to plan. Sheda reviewed the situation, 'First of all I had broken sleep, because Hussain was a bit unsettled last night. So I woke up couple of times,

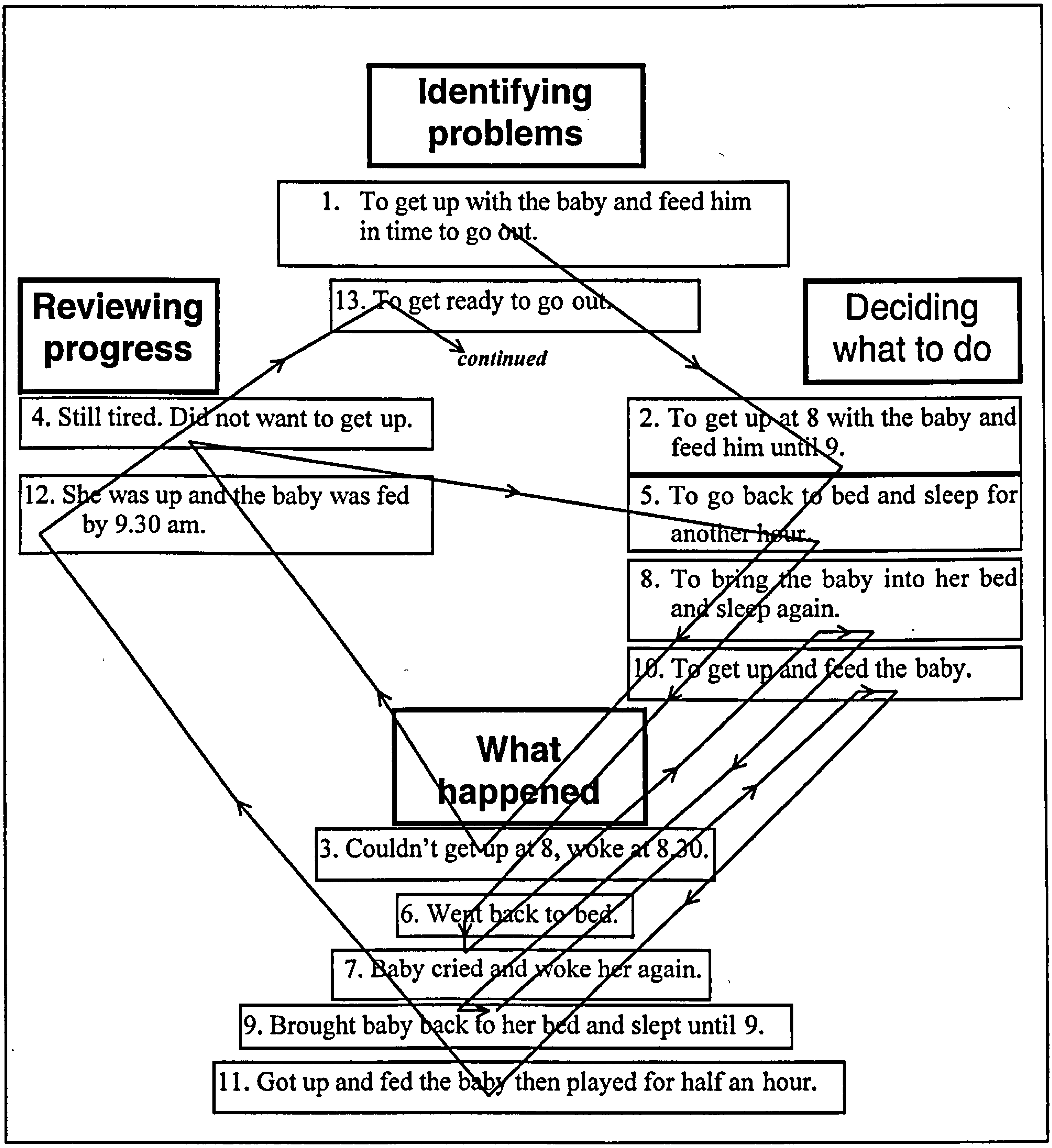


Fig. 5.6. The stages in Sheda's account of solving the problem of getting ready to go out.

then I couldn't get up at 8 o'clock. I woke up at half past eight. I went into the living room to look at the clock on the wall. It was half past eight. I said " Oh." Still I was a bit tired.'

She had a new contributory problem of getting more sleep, so she made another plan, 'I say, "Let me go back to bed and sleep for another half an hour."' But that did not work out either. 'Hussain got up and start crying.'

Sheda made a fourth plan, 'I took him out of his cot and put him beside me in the big bed.' She got half way to getting her extra hour's sleep, 'Finally I get out of bed at 9 o'clock.'

She then continued with her original plan, modified to a later time. 'Then I start feeding Hussain his milk and his breakfast. I think I finish it at half past nine.' Then she did something she had not previously decided to do, 'For another half hour I play with him.' Then she continued with her original plan of getting herself ready to go out, 'I have my breakfast.'

A new contributory problem emerged: to leave the baby with her husband. Sheda must have known at the outset that she needed to make sure that her husband was awake before she left the baby with him. She did not state this at the beginning of her story. In giving her account, she probably only remembered this aspect of the problem when she got to this point in telling the story. In her actual experience, she may have only become aware that she needed to get her husband up, when she was ready to leave the house. Or, she may have been aware of it all the time, but only acted when it became necessary.

To get her husband up, she first had to wake him, another contributory problem. 'At 10 o'clock ... he was still in bed and he wanted to continue. He said, "Oh, I'm tired."' Sheda made a plan and carried it out, 'I took Hussain and both of us walked to his room, and we say, "OK, get up. Hussain, wake up your dad, it's time Mum should leave."' The execution of this plan eventually produced the desired result, 'He managed to get up at half past ten.'

At a quarter to 11, when she tried to carry out her plan of leaving the house, the baby stopped her. 'But Hussain cried when he saw me leaving. He wanted to be picked up and he wanted me to walk with him.' So she revised her plan, played with Hussain for ten minutes and then left the house. 'I left home at 7 or 8 to 11.' She was now on her way to the group. She had decided to walk to Chelmsford Square to catch the bus. At this point she reviewed her progress again, 'I thought, "Oh, I'll be late."'

Then her plan went wrong again, 'The bus didn't come. I waited for about 5 minutes.' So she reviewed the situation again, 'Then I thought, as it was Sunday, maybe it won't come soon, so I said, " Oh, I shouldn't wait any longer." She made another plan, 'I walked. Always I was checking behind to see if it was coming so that I could run to it at the next stop. But I didn't see one.'

At the group she reviewed her plan, 'It took me about 35 minutes from home, so good exercise. I was quite right that I didn't wait, because I wouldn't be here, I would wait for bus.' As she was giving her account to the group, she reviewed the whole situation, 'That's why I was late, things didn't happen the way I plan it.'

Sheda started off with a clearly identified problem: to get to the group at 11 o'clock. She recounted piecemeal the plans she made which identified the contributory problems that she needed to resolve in order to resolve this compound problem: to get her baby up at 8 o'clock and feed him by 9 o'clock, to get herself ready by 10 o'clock, to get her husband up so that she could leave the baby with him, to walk to Chelmsford Square and catch a bus to the group venue. She had calculated the time she needed for each contributory problem. She reviewed what had actually happened from when she woke up late, and at each stage of the proceedings, and reformulated her problems and how to resolve them as she went along.

Sometimes she did not state her plan and describe carrying it out separately, 'I walked. Always I was checking behind to see if (the bus) was coming so that I could run to it at the next stop.' She is recounting what she did, and the plan to do it is implied, an example of indexicality (Garfinkel, 1968). If she had not decided to walk she would have waited at the bus stop until the bus came. She may have made the plan to keep looking behind her, either before she started walking or while she was walking.

Some of the contributory problems, for example to get her husband out of bed, only emerged during the process of resolving her main problem of getting to the group on time. Others, though formulated at the outset, were modified during the process of solving the problem, for example getting up at nine instead of eight. This example shows how a participant set out to resolve a problem, getting to the group at 11 am, but during the process of solving it, had to resolve several contributory problems.

5.3.2.3 Solving routine problems

Many of the problems that I observed the participants solving, or that they recounted to me, were routine: they were problems that they had resolved many times before, albeit with minor variations (Hoyles et al, 1999, Lave, 1988, Gal, 1999). The participants did not necessarily designate such activities as 'solving problems', they were more likely to say that they always did something a certain way.

Where participants were resolving problems that they constructed routinely, no planning or review were necessary. This is represented in the cyclical logical part of the model (Fig. 5.1) by the arrows, which show movement directly from the identification of problems to the execution of plans, in this case the plans being the routine ones for these particular kinds of problems. No further action would be necessary, unless the participant found that his routine plan did not work in a particular case for some reason, perhaps circumstances having changed. In such cases the participant would move on to the review stage and then on to re-identifying the problem, making a different plan, carrying that out and then reviewing the result again.

An example of the successful solution to a routine problem is Cathy's method of managing her personal money. The problem she identified was always to know exactly how much money she had in her bank account, when she knew that her bank took time to register transactions on her account. 'Because the statement doesn't agree. Because it might be, you know, three days old, or something. You might have paid more money off.' She explained how she kept track of her transactions, 'I always write down every single thing I take out of the bank or do a cheque on or Switch.' She described a positive resolution of her problem, 'So I know exactly what I've got in there at that present moment.'

But sometimes routine solutions were not adequate and problems had to be reformulated. Below is an example from the data where the participant's routine method broke down, because circumstances had changed. In Section 5.2.2.2, I described Jean's method of managing her personal finances, by intuition rather than calculation, which worked well while everything happened routinely. But Jean ran into a problem when her pay-date was moved.

> The organisation I work for has moved our pay date. ... Formerly we were paid three weeks in advance and by the end of the, by the end of next month which is November we are going to be paid at the end of the month, around the 27th or 28th, something like that. So they have actually staggered each pay-day just that little bit later.

She suddenly found that her sense of how much money she had was wrong. 'I was overdrawn, for the first time in years, a couple of months ago. ... My financial clock has been thrown out of balance.' Managing her money had been a routine problem for Jean: she had a regular income and regular expenditure and she knew that her income covered her expenditure. When the routine event of getting paid on a certain day was changed, Jean's management of her money was upset.

The central part of the cyclical logical model (Fig. 5.1) represents the simpler problems, the complex problems, the compound problems, and the routine problems. The model is cyclical, showing that the four phases of logical problem-solving could each be revisited several times, if necessary, before the main problem was resolved.

5.3.2.4 Logic in school maths problems

A similar logical structure is also apparent in the solution of school maths problems. What is different from solving everyday problems is that the student does not identify or construct the problem. It is written by the teacher, the text-book writer or the test writer and given to the student. So that the first stage in my four-stage model is not experienced by the student. She begins at the next stage of the model: she formulates a plan. She continues to the next stage, executing the plan. These two stages may be conflated. The fourth stage may also not be experienced by the student. The teacher or the test-marker, not the student, is the arbiter of whether an answer is appropriate. If the answer is wrong, nothing may happen if the problem is part of a test. If the problem is being used as classwork, the student may be required to go back to the planning stage. Or the teacher may demonstrate the execution of her own plan for solving the problem, in which case the student may be required to do the calculation rather than the problem-solving. The lack of ownership of the problem may result in a lack of interest in the problem-solving process at the review stage. The student's interest may be more focussed on gaining a mark than on how to do the problem.

In the example of the maths problem about different kinds of books sold by a bookshop (Fig. 5.5), the candidate needs to understand the concept of a pie-chart, which involves knowing the angular properties of circles and understanding proportionality. The problem also requires logical thinking within the planning and executing stages of the problem-solving process. The writer of the question has made the actual calculations relatively easy to a candidate who knows that there are 360^0 in a circle and recognises that 720 is twice 360. The problem-solver could review this result by assessing that section A is almost half of the pie, so that 340 seems like a reasonable answer, but she may not do so.

In this section, I have argued that there are underlying four-stage cyclical logical structures in the problem-solving that was described to me by the participants or that I observed in the course of the study. The model (Fig. 5.1) represents these logical structures and shows the different processes the participants used in constructing and resolving problems, as well as showing that problem-solving is embedded in the socio-cultural contexts of the participants' lives. I also argue that solving traditional school maths problems uses a reduced set of these logical processes and happens in different contexts to those that feature in the problems.

5.4 Summary

In this chapter, I derived a model from the data of the construction and resolution of everyday quantitative and spatial problems (Fig. 5.1). It represents the socio-cultural context of the activities in which the participants in my study were involved in their everyday lives and in which they constructed and resolved quantitative and spatial problems. It identifies the mainly informal, and sometimes idiosyncratic, methods, tools and conventions, that the participants used or followed in their problem-solving. It denotes the influence of the participants' social relationships on their problem-solving. It also represents the four-stage cyclical logical structures of the participants' problem-solving, taking into account the different levels of complexity of problems.

I have addressed my first and second research questions (Section 2.6). Although the main focus of my study was not educational provision, I found very fundamental differences between school mathematics problems and their solutions and the problems the participants in my study constructed and resolved. The analysis of the data reinforced my serious concerns about the links made in the Skills for Life strategy (DfEE, 2000) and the Adult Numeracy Core Curriculum (Basic Skills Agency, 2001) between school maths and performance in everyday activities. In Chapter 7, I discuss the implications of my findings for adult numeracy education.

In Chapter 6, I continue to report on my data and address my third research question (see Section 2.6), focusing on how attributes of individuals, their previous experiences, their emotions and identities, influence quantitative and spatial problem-solving in everyday life. I further develop my model to represent the interaction between the individual, the socio-cultural context and the structures of problems and their solutions.

Chapter 6. The agency of the problem-solver in the construction and resolution of problems in everyday life

6.1 Introduction

In Chapter 5, I reported on the results of my study, focusing on research questions 1 and 2 (see Section 2.6), which are concerned with the socio-cultural contexts and the structures of everyday problems and their solutions. I presented a model (Fig. 5.1), from the analysis of data, which demonstrates the relationship between the socio-cultural contexts of problem-solving and the complex, cyclical, logical structures of problem-solving processes. In this chapter, I present a more holistic version of my model (Fig. 6.1), which demonstrates the relationship of these attributes of the problem-solver with the socio-cultural contexts and problem-solving processes in everyday life. I continue to report on the results of my study, focusing on Question 3 (see Section 2.6): I consider how the agency of the individual participant influenced the construction and resolution of everyday quantitative and spatial problems. In particular, I focus on three attributes of individuals, which I found influenced problem-solving processes and which are largely ignored in traditional maths education: their previous experience, their emotions and their identities.

6.2 A new holistic model to describe problem-solving in everyday situations

In this section I propose a new version (Fig. 6.1) of the model that I presented in Chapter 5 (Fig. 5.1). The new model represents the holistic nature of problem-solving in everyday life. It denotes the socio-cultural contexts of the activity and the complex, cyclical, logical process as before. It now also includes the problem-solver as agent, represented by the dotted oval at the centre of the model, with three attributes: her or his previous experience that they bring to the situation, her or his emotions which are involved in the solving of problems, and her or his identity. It has been difficult to find a theory that fully explains my data and makes a coherent story about the context and the processes of problem-solving and the problem-solver. Traditional theories have focussed on the cognitive process. The more recent socio-cultural theories have focussed on the social contexts in which learning takes place and have an underlying assumption that all individuals have similar experiences (Lave, 1988; Lave and Wenger, 1991; Wenger, 1998). Neither perspective gives the whole picture of what is a very complex process. The purpose of the model is to communicate to researchers, policy makers and professionals in the field of adult numeracy education the complexity of problem-solving in everyday life, to inform their practices.

6.2.1 Previous experiences

Lave's (1988) and Lave and Wenger's (1991) theory of situated cognition describes knowing as an interaction between people and the communities of practice to which they belong. The individual's knowing is equivalent to her or his degrees of membership of communities of practice, from newcomer to old-timer, and her or his identity within those communities of practice. In the original exposition of the theory, a participant cannot transfer knowledge from one community of practice to another (Lave, 1988, Lave and Wenger, 1991). A later interpretation describes people as members of many different communities of practice, sequentially and concurrently, and their identities as products of all their different memberships (Wenger, 1998). According to this interpretation, experience in one community of practice can be called upon in another community of practice. This later formulation of socio-cultural theory seems more realistic: the earlier ones seemed to assume that all members of a community of practice had the same experience, over different time-scales, moving from 'legitimate peripheral participation' to mastery over a number of years (Lave and Wenger, 1991), with no effect from experiences outside of the particular community of practice.

In Chapter 5, I adapted three of Saxe's (1991) four parameters of problem-solving to represent aspects of the socio-cultural contexts of problem-solving in my study. The fourth parameter in Saxe's model, prior understandings, refers to the agent and to time, that the agent knew something, at a previous time to the situation under consideration and can access it later, in the new situation. This fourth parameter is therefore not socio-cultural, it represents an attribute of the individual. I shall refer to this parameter as 'previous experiences', to emphasise that it was experiences which participants brought to new situations.

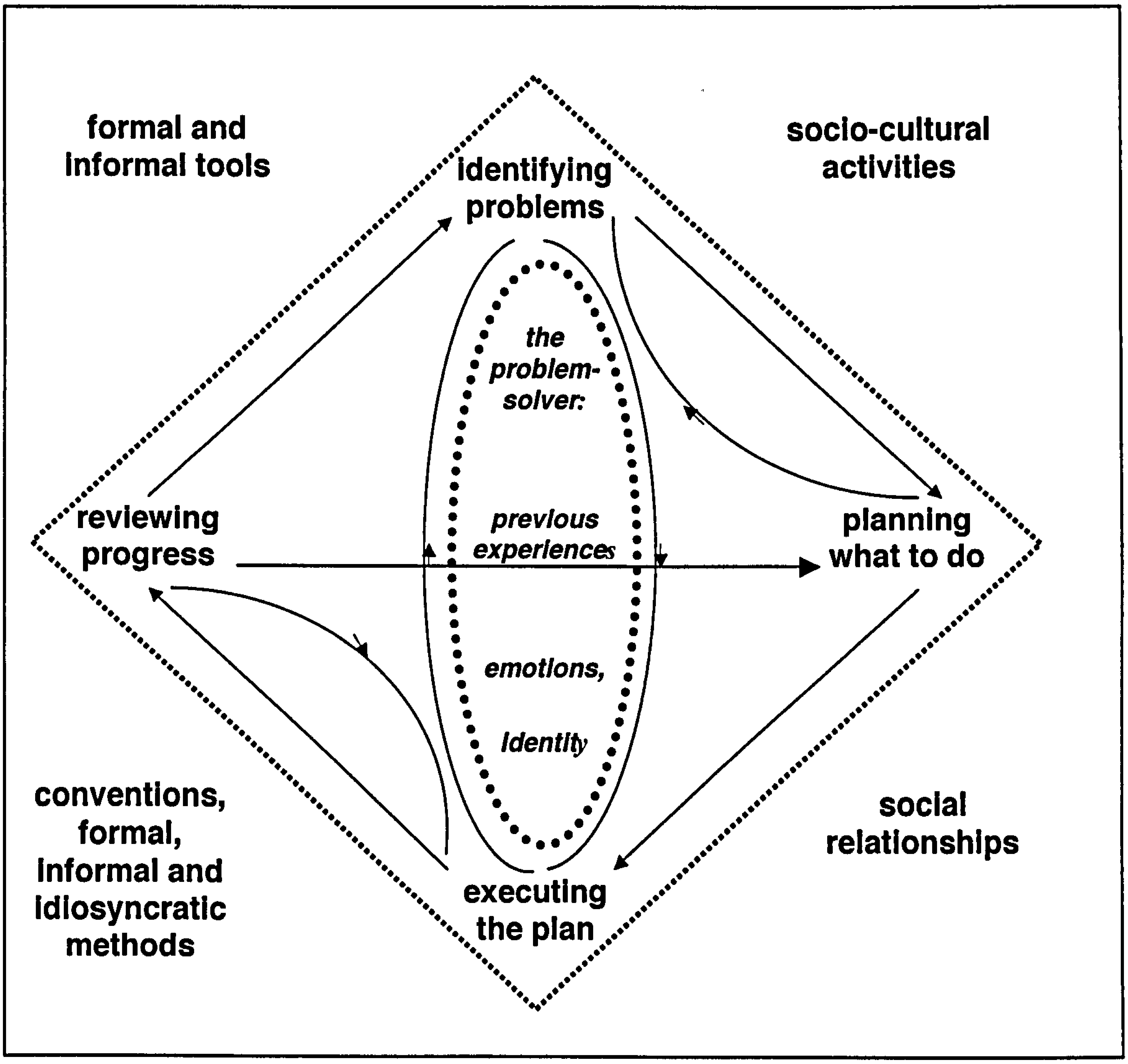


Fig. 6.1 The relationships between the problem-solver, the complex, cyclical, logical structure of problem-solving and the socio-cultural contexts

		WHAT IS KNOWN		**FEELINGS**
		Knowing *how to do* things (procedural, prescriptive)	**Knowing *about* things or situations** (descriptive, contemplative)	
HOW SOMETHING IS KNOWN	**Explicitly** (consciously)	Explicitly knowing *how to do* things	Explicitly knowing *about* things or situations	Explicit Feelings
	Implicitly (unconsciously, tacitly, intuitively)	Implicitly knowing *how to do* things	Implicitly knowing *about* things or situations	Implicit intuitive feelings

Fig 6.2 Modification of Tomlinson's (1999) matrix

To examine what previous experiences might consist of, I turn to Tomlinson's (1999) matrix (p 417) (Fig. 2.1), which has a very different perspective of what people know from Saxe's (1991) model (Fig. 2.2). In his matrix, Tomlinson uses the traditional idea of knowledge as something that a person possesses and that can be examined, without considering the socio-cultural context in which she is situated. It focuses on the individual, who has the knowledge, and on what they know. In this view, knowledge can be of various kinds, without reference to the situation of the person who knows. Two of Tomlinson's categories, 'deliberative action capacity' and 'intuitive action capacity' (p 417), refer to practical knowledge people have of how to do things and distinguish between whether the knower is aware of the knowledge or not. Although derived from a different theoretical perspective, these two kinds of knowledge do fit with the socio-cultural theory of knowing, in the sense that they are about action. But the term 'capacity' seems to refer to knowledge contained within the individual, which does not fit with the socio-cultural perspective. I have renamed these two categories of knowledge 'explicitly knowing *how to do* things' and 'implicitly knowing *how to do* things', so that I am now using the active verb, 'knowing', rather than the static noun, capacity, while retaining the distinction between being aware or unaware.

Tomlinson's (1999) other two categories of knowledge, 'explicit representational awareness' and 'implicit representational awareness' (p 417) (Fig. 2.1), refer to theoretical knowledge that people have about things or situations. These categories as they stand do not fit into the socio-cultural perspective, because, again, they are about people possessing knowledge. I have renamed these two categories 'explicitly knowing *about* things or situations' and 'implicitly knowing *about* things or situations', changing the terminology from the passive noun 'awareness' to the active verb 'knowing'. But these categories are still about theoretical knowledge that someone possesses, rather than about the interactions between a member and her or his community of practice. These four categories of knowledge, considered together, are a way of dissecting Saxe's (1991) parameter, 'prior understandings' (p 17), or previous experiences, as I am referring to it, providing the distinctions between knowing theoretically and practically and between knowing explicitly and implicitly. In Section 6.3, I discuss evidence from my study of individuals' previous experiences contributing to their qualitative and spatial problem-solving in their everyday lives. I turn now to the roles of emotion and identity in qualitative and spatial problem-solving in everyday life.

6.2.2 The roles of emotion and identity in problem-solving

In this section, I argue that as well as the previous experiences that the participants brought to their problem-solving, emotions were important influences on how they constructed and resolved quantitative and spatial problem-solving in their everyday lives. I also argue that, in some situations, the participants were not aware of emotions that appeared to be influencing their problem-solving activities. Tomlinson (1999) did not consider emotion or identity in relation to cognition. I have therefore amended his matrix to include emotions, those which were explicitly expressed and those of which the participant may not have been aware, but which may have influenced her behaviour or been revealed in the words she used (Fig. 6.2). The modified matrix more fully represents my data: in addressing problems that emerge in their everyday lives, people draw on their knowledge of *how to* do things, their knowledge *about* things or situations and they are influenced by their emotions in how they construct problems and find solutions. They may experience knowing different kinds of things and feelings explicitly, or they may be influenced by them in how they act, without being aware of them.

Saxe's data had many examples of how emotion impacted on his candy-sellers' activities. For example, he describes how the wholesalers' clerks were especially kind and helpful to the children when they were purchasing their sweets and also that the children's customers only bought sweets because they were sorry for the children. Also the older children helped the younger ones in choosing sweets to sell and how much to sell them for. He also reported that there was conflict between the children over their selling sites. But Saxe did not include emotion in his model of culture and cognitive development.

Emotion and identity both feature in Lave's (1988) theory of cognition in practice and identity is a fundamental concept in Lave and Wenger's (1991) theory of situated learning and Wenger's (1998) theory of communities of practice. However, neither of these authors has categorised the different emotions that impact on problem-solving in everyday life and their relationships with participants' identities. I found that there were three main categories of emotion in my data: feelings of confidence or lack of confidence; emotions that influence preferences and choices; and emotions in social relationships. Each of these categories of emotions was closely related to the participants' identities.

I am using Wenger's (1998) definition of identity in relationship to participation in social practice and learning. He saw participation in communities of practice as 'a complex process that combines doing, talking, thinking, feeling, and belonging. It involves our whole person, including our bodies, minds, emotions, and social relations (*Ibid,* p 56).'

> Theories of *identity* are concerned with the social formation of the person, the cultural interpretation of the body, and the creation and use of markers of membership such as rites of passage and social categories. They address issues of gender, class, ethnicity, age, and other forms of categorization, association, and differentiation in an attempt to understand the person as formed through complex relationships of mutual constitution between individuals and groups (Wenger, 1998, p13).

Wenger (*Ibid*) saw people as belonging to many communities of practice, but having one identity made up of the interaction of the 'multimemberships' (p 105). He defines learning as 'the vehicle for the evolution of practices and the inclusion of newcomers while also (and through the same process) the vehicle for the development and transformation of identities (p 13).' In Section 6.4, I discuss evidence from my study of the roles emotion and identity played in the construction and resolution of quantitative and spatial problems in everyday life. In Chapter 5, I discussed differences between problem-solving in everyday life and in traditional maths education. In the next section, I look at how the roles of previous experiences, emotion and identity make for other differences between problem-solving in school maths and everyday life.

6.2.3 Differences between school maths and everyday problem-solving

Traditional school maths problems and their solutions are constructed around mathematical procedures and embedded in invented contexts, for example the problem in Fig. 5.5. The student is not expected to identify and respond on a personal basis. Only her previous experience of maths is considered relevant. In that example, this would be her experience of using the angular properties of a circle and proportion to solve problems. Her experience of the context, of bookshops, any emotion she might feel about them, her identity in relation to bookshops or the mathematics are not considered.

It is now recognised in maths education that doing mathematics is not the emotionless process it was long considered to be. Educational research has found that students' emotions about doing maths influence their performance in maths (Buxton, 1981, McLeod, 1989 and 1994, Fennema, 1989, Ma and Kishor, 1999). These studies focus on feelings about calculation and doing school maths problems. Evans (2000) has shown that students' feelings about the context of maths problems can influence their abilities to solve them. The setting of Evans' study, as a university lecturer giving students a test and then interviewing them individually about their responses, was more of a maths education than an everyday situation. He employed the problems that Sewell (1981) used in the second part of her study of everyday maths. They had everyday contexts, for example, choosing food in a restaurant. Some of the questions were closed and some were more open than traditional school maths problems, but with a limited range of possible answers. They were not complex or compound in the way that many of the problems in my study were, as I described in Sections 5.3.1.2 and 5.3.1.3. The questions were designed to represent everyday problems, but they were written by a researcher and therefore not owned by the students (Lave, 1988). In the interviews, the students talked about experiences in their lives outside of education and their feelings about situations that the contexts of the questions evoked. Evans showed that these influenced the students' problem-solving performance. I argue that my participants' previous experiences and their emotions and identities influenced the construction and resolution of problems in their everyday lives.

In Chapter 7, I discuss the implications of these differences between school maths problems and everyday problems for teaching and learning adult numeracy. In the following sections, I present evidence that participants' previous experiences, both what they knew how to do and what they knew about, and their emotions, both explicit and implicit, were all important attributes which they brought to bear on constructing and resolving quantitative and spatial problems in their everyday lives. I also present evidence that the third personal attribute, identity, is closely related to emotion.

6.3 Previous experiences

In this section, I discuss how individuals' previous experiences influence how they construct and resolve problems.

6.3.1 Different previous experiences

The different previous experiences of different people in a community of practice can be illustrated by reference to the gardening firm in my study, which was a community of practice, within the larger community of practice of professional gardening. The gardening firm was run by Joe, who could be described as a master gardener. Ben and Gerry were informal gardening apprentices, with a little experience, but one of them was in danger of getting the sack. Freddie was another apprentice, who had been a pop-star, and had subsequently had his own allotment, and did get the sack for incompetence. Mick really belonged to the community of practice of builders, but joined the gardening firm for a few weeks. Lee, a very experienced gardener, but not, perhaps, quite a master gardener, who had worked for Joe and with other gardening firms, had left Joe's firm to become a student of English Literature and had returned on a temporary basis to earn some money. These six workers, therefore, had very different trajectories within the communities of practice of professional gardening and of Joe's firm. The experiences that they had had in their lives outside of Joe's firm affected how they worked for the firm. For example, Mick had learnt his building skills outside of Joe's firm, but this experience determined how he practised those skills while working for Joe.

6.3.2 Knowing practically and theoretically

The participants in my study demonstrated that they knew how to do many things and about many situations and they used what they knew in solving problems in their activities in their everyday lives. What they knew had different forms. For example, there is a difference between having the practical skills of using gardening tools, and knowing theoretically about the properties of plants. Fig. 6.2 shows this distinction.

Sometimes it was difficult to categorise what I had seen or what I had been told. For example, in the upholstery class, Sean and his students had experience of handling the various materials. If I identify this knowledge as 'how materials behave', then it belongs to the category of 'knowledge about things or situations'. But if I call it 'knowing how to handle materials', then it should be categorised as 'knowledge of how to do things'. The difference between these two categories is that one is theoretical knowledge about materials and the other is knowledge of what to do. It was not always possible for me to distinguish between these categories in what I was observing.

6.3.3 Knowing explicitly and implicitly

Fig. 6.2 also shows the difference between knowing implicitly and explicitly. In the course of gathering my data, when someone told me *how to do* something or *about* something, I knew that they were aware of what they knew. When I had observed someone doing something and they had not told me about it, I surmised that they might not be aware of knowing about it. Identifying that someone knows implicitly or intuitively *about* things or situations is more difficult to do: it cannot be observed because it is not action and it is not described because the person is not necessarily aware of it. It is something that people know, of which they might not be aware, and yet they can use to solve problems. It can therefore only be conjectured by a researcher.

An example of knowing about something implicitly is the way that Cathy chose books for the college library where she worked. She described to the Everyday Maths Group how she made decisions about buying books, as I reported in Section 5.3.1.2. She collected a lot of explicit information about the content of possible purchases and their potential usefulness to students. Choosing what to buy was a complex problem with a large number of variables, both qualitative and quantitative. Cathy considered all the variables explicitly, but found solutions intuitively. 'It is slightly, deciding what to buy is quite, instinct. You can't really say anything. I mean the accounting is solid, but it's instinct deciding what to buy.' She set out to make the decision in a very objective way, but the problems were too complex to solve in a deliberate way (Damasio,1996) and it would have required assigning weights to the different qualitative criteria. She therefore trusted her intuition to produce a sensible decision. She used a combination of 'explicit knowledge of how to do things', when she followed various procedures for investigating things like how many copies of a book the library had and how often a book had been borrowed, and 'explicit knowledge about things or situations', when she used her knowledge about the content of books and syllabuses. When it came to making the decision about which books to buy, she used 'implicit knowledge of how to do things or situations' and possibly her 'implicit knowledge about things', what she calls 'instinct'.

6.4 The relationship between emotion and identity and their influence on problem-solving

In this section, I consider the evidence from my study of the roles emotions and identity played in the participants' structuring and solving of everyday quantitative and spatial problems. I examine the different emotions that occurred in the data, their relationship with the participants' identities and the impact of both on problem-solving by the participants. I am considering emotion and identity together because I found that they were closely linked in the data.

I found three main categories of emotion in the data. First, I discuss how feelings of confidence were linked to the participants' identities and affected how they constructed and resolved problems. Second, I discuss my findings that, when in situations where they expressed a preference or had to make choices between different ways of solving problems or doing things, the participants often acted on the basis of their emotions, and these were linked to identity. Third, the participants' identities and their emotions, embedded in their social relationships, strongly influenced the way they structured and addressed problems. I then consider what constituted satisfactory resolutions for the participants (Lave, 1988) I found that they did not always depend on pragmatism, as I discussed in Section 5.2.6. Sometimes they depended on the participants' feelings.

6.4.1 How feelings of confidence in problem-solving varied and their relationship to identity

In this section, I consider the participants' feelings of confidence in addressing problems in which they were engaged atwork or in other activities together with the relationship of these feelings of confidence to identity. Burton (2004), when writing about learning mathematics, defines confidence as 'a label for a confluence of feelings related to beliefs about the self and about one's efficacy to act within a social setting.' (pp 357-381.) I consider the relationship of confidence to competence, or efficacy, and to degrees of membership of communities of practice and therefore to identity (Lave and Wenger, 1991). I show that confidence can be misplaced. Next I discuss how implicit lack of confidence in using formal tools and methods of calculation probably affected how members of the Everyday Maths Group solved problems in their everyday lives. Then I consider how the participants' confidence varied from one situation to another.

6.4.1.1 The relationship of confidence to competence

Most research on emotion and mathematical cognition has focussed on the relationship between learning and maths anxiety, i.e. lack of confidence in learning and using maths (Buxton, 1981, McLeod, 1989 and 1994, Fennema, 1989, Ma and Kishor, 1999; Bibby, 2002). Maths anxiety was an issue in recruiting participants for the study (see Sections 3.5.3 and 4.3.3). It also emerged as a small part of the data from the Everyday Maths Group. There were three women in the Everyday Maths Group who stated without embarrassment that they had difficulty with calculation. Bibby (2002) identifies this way of coping as 'verbal protection through self-denigration' (p 716), suggesting that people defend themselves against potential criticism by saying that they cannot do maths. I think, in the case of my participants, it was also a way of warding off any potential demand from me that they should perform any calculations in the group, even though I had promised them that I would not ask them to do this. One participant, Ruth, expressed acute anxiety about anything to do with numbers, an extreme form of lack of confidence.

Belonging to a community of practice (Lave and Wenger, 1991), that is having an identity as a member of that practice, tended to invoke feelings of confidence. Being on the periphery of a community of practice invoked feelings of lack of confidence. To some extent, confidence is a reflection of competence: where the participants had knowledge about and experience of their activities, they tended to be confident about their ability to solve any problems that arose during the course of those activities. Many of the participants displayed a lot of confidence in addressing the problems they met in their everyday lives, particularly in their work, where some of them had a great deal of expertise. They tended to have identities as full members of communities of practice (*Ibid*). There is therefore a connection between levels of confidence and degrees of membership of communities of practice (*Ibid*) and consequently identity. However, there were situations in the data where the participants were confident without being competent.

6.4.1.1.1 Professional competence and confidence

Joe, the gardener, and Sean, the professional upholsterer, were both very experienced in their fields and were confident about tackling the problems that arose during the course of their work. Each garden and each piece of furniture required the solution of various quantitative and spatial problems and, with a few exceptions, the workers approached these with confidence and effectively solved them.

Joe had been running his gardening business for a number of years and he was very knowledgeable about gardening and had a lot of practical skill. He was very confident when he talked to me and to potential customers about what he could do and he set about his work in a confident manner. During his work, he had to solve different kinds of quantitative and spatial problems, as I described in Section 5.3.1.3. He had to measure the sizes of the gardens and different parts of the gardens, sometimes to estimate and sometimes to calculate exactly lengths, areas, perimeters and volumes, and deduce estimates or exact amounts of the materials required. He had to decide on the sizes of plants, at the time and how they would grow, and how to arrange them in the space available. He also had to work out the most appropriate order in which to do things. Joe was very confident about doing all these things.

In order to cost jobs realistically, Joe had to estimate how much time his different workers would need to spend on the various tasks required and to take into account things like the weather and the possibility of deliveries of materials being late. Joe was less confident about this aspect of the work. He asked me, when I first started to observe his work, to tell him if I had any ideas about how he could manage the work better. Joe introduced me to the owner of the Larch Place garden as 'a time and motion study expert'. I am sure this was meant as a joke, but it possibly also revealed what he felt he needed. Joe told me that he was having trouble with recruiting, training and retaining suitable staff. His two young 'apprentices', Ben and Gerry, worked well when he was around to oversee them. He had trained them particularly in the erection of fences and he felt that they were capable of doing this on their own. However, he said that as soon as he went off to do an estimate visit, or to buy plants from the nursery, leaving them to work on their own, they slackened off and did not get much work done. He said that he had tried encouraging them and tried threatening them and neither strategy had had much effect. He was considering sacking one of them to see whether the other would work better on his own. In addition, Joe had had trouble with Mick, the builder whom he had sub-contracted to do the hard landscaping at the Yew Tree Road garden (described in Section 5.3.1.3). So Joe was very confident about gardening, but less confident about the management side of the business: managing his workers and subcontractors and managing their time. These levels of confidence relate to Joe's identity: he had a strong identity as a gardener, but his identity as a manager of other workers was less well-developed.

Sean was a very experienced upholsterer and appeared confident about tackling the problems that arose during the course of his work. Each piece of furniture required the solution of various quantitative and spatial problems and Sean seemed to approach these with confidence and effectively to solve them. He explained to me that he had learned furniture-making and upholstery in his father's workshop, in Ireland. He said that when he was very young, he was told that he could watch his father working, but must not touch anything. From the age of eight or nine he started making small things and, by the time he was fourteen, he was making chairs. This experience is very similar to the traditional apprenticeship system of learning discussed by Lave and Wenger (1991), resulting in Sean being a competent upholsterer and having a strong identity as one. Although Sean trained to be an architectural technician, he eventually reverted to being an upholsterer. He told me that, out of five brothers and sisters in the family, four were working in furniture making and design, at the time of the study.

In comparing Sean's and Joe's confidence in their professional work, it is important to bear in mind that although Joe expressed and revealed a lack of confidence in some situations and Sean did not, this may have been because Joe was more willing to be open about his feelings than Sean, rather than that he was a less confident person. Also, Joe's work involved a wider range of skills than Sean's. Joe had to deal with fencing, paving, building walls and decks, laying turf, planting, weeding and pruning. He was also managing a staff of three people and he was continually working in new locations, which did not belong to him. The practice of upholstery also consists of a range of different tasks: stripping down furniture, repairing and altering frames, securing webbing, springs, two kinds of stuffing, hessian, calico, buttons, and the top fabric or canes. But Sean was not managing staff. In the upholstery class he was managing students, but he was not dependent for his income on how quickly and effectively they worked, only on whether they attended the class. He was still paid the same amount to teach them. Sean always worked in the same two locations: the community workshop and his professional workshop.

6.4.1.1.2 Misplaced confidence

Sean was also an experienced teacher of upholstery, who appeared to be very confident about his method of teaching. However, I consider that Sean's confidence as a teacher was misplaced, because, although his students were doing upholstery, over half of them were lacking in confidence and were not learning how to upholster independently. He had very definite views, which he explained to me, on the best way to teach upholstery. They appeared to be based on his experience of learning from his father as a child. Sean believed that his students learned best by doing upholstery, not being told about it. He told the students that they should take careful note of the construction of the upholstery, when they were stripping down the furniture, so that they could build it up in the same way. The students each brought in her or his own chair or sofa and were shown what to do individually by Sean, although other students sometimes gathered round to watch. Then the student was left alone to do what they had been shown. Sometimes she or he could not manage it, or could not remember exactly what to do, and she or he had to ask Sean to come back and show the process again. Sometimes another student would help.

Sean told me that a student would often ask him what her or his next upholstery task would be. He said he always told them, 'Wait and see.' He said that this added excitement to the process. He did not think that they would gain anything from being told about upholstery procedures, before actually performing them. Sean also did not use writing about, or visual images of upholstery in his teaching: there were no pictures, diagrams, books or worksheets in the workshop. He did take photographs of the students and their pieces of furniture, in various stages of stripping down and re-upholstery or re-caning, and showed them to the students at the end of term, so that they could review their progress.

Sean was making the same distinction between learning upholstery by doing and learning by talking about it that Tomlinson (1999) made between knowledge of how to do something, practical knowledge, and knowledge about something, theoretical knowledge.

Although the workshop had some similarities with the apprenticeship system described by Lave and Wenger (1993), there were also some fundamental differences. In the apprenticeship system, experts usually only have two or three apprentices each, at different stages of learning the craft (*Ibid)*. The experts practice their craft. They do not instruct apprentices, who learn from watching the whole process, and by attempting peripheral tasks to begin with and gradually working towards practicing the central tasks (*Ibid)*. Sean did not do any of his own upholstery work in the class. He spent his time instructing his seven students individually.

Many of Sean's upholstery students had been attending his class for a number of years. Out of the seven students in the class, three of them, Carol, Evelyn and Felix, seemed confident about what they were doing, shown by the way they worked quickly and effectively. But the other four students, Alice, Beattie, Denise and Grace, were very lacking in confidence, which was apparent from their very slow and hesitant approach to their work and the fact that they often had to wait for Sean to come and show them what to do, sometimes more than once. Two of them also told me that they could not possibly do upholstery without Sean to help them.

Beattie was re-upholstering a button-back chair. She had not done one like it before. Part of the process was to make false removable buttons out of webbing and attach them to the chair on top of its hessian under-cover, in the positions where the real buttons would finally go. There were two different kinds of false buttons, one kind for the front of the chair and another kind for the back. Sean showed Beattie how to make the front button by folding a small square of webbing in half and making a stitch with a large needle and twine across the fold. He then removed the needle from the twine and threaded both ends of the twine through the needle together. Then he pushed the needle right through the chair from the front to the back. He removed the needle and attached the second false button, which was a rolled up small square of webbing, to the chair, by tying the ends of the twine over it in a double half hitch. Sean then went off to see another student and left Beattie to put on the other false buttons. Beattie tried to repeat the process she had just been shown, but she immediately got confused and threaded both ends of the twine through the needle, before she had made her stitch through the front false button. Then she pushed the needle once through the square of webbing, without folding it. She had to call

Sean over again to watch her working through the whole process and correcting her when necessary. A single demonstration of a process with several stages is probably not enough input to enable the watcher to be able to repeat the process unaided. The result, in this case, was that the student was not able to follow the process without further support. If she had had an instruction sheet, she might have been able to use it to remind herself of the various steps in the process. But I think Beattie's lack of confidence was also a factor in her not being able to reproduce the process without help.

There was an opportunity at the craft workshops for the students to come in on an additional day to work on their furniture. Sean would not be there, but a technician would be available to help. When I asked several students, who had told me that they had been attending the class for many years, whether they worked on their upholstery outside the class time, they were horrified, saying that they could not possibly work without Sean to help them. Two of the students also told me spontaneously, on separate occasions, that they could not practise upholstery without Sean's help. Denise said that she would not know how to fix the broken frame of her chair without Sean's help. Beattie told me that every chair presents different problems. They lacked confidence in their abilities to do upholstery independently and this affected their participation in the activity of upholstery: they were not able to take advantage of the opportunity to work on their upholstery on another day of the week. I suggest that one factor in the four students' lack of confidence was that they were totally reliant on Sean to show them what to do. I discuss this situation further in Section 6.4.3.1.

The community of practice (Lave and Wenger, 1991) of upholstery teachers is probably very loosely constituted, being small and geographically scattered. Sean may have had no contact with other teachers at all, relying for his teaching methods on his experience of learning from his father. Whereas his membership of the community of practice of upholsterers was central and therefore his identity as an upholsterer was strong, his membership of the community of practice of upholstery teachers was probably more peripheral and his identity as an upholstery teacher was therefore weaker.

6.4.1.1.3 Implicit feelings of lack of confidence

There were situations where the participants' implicit feelings (Evans, 2000) seemed to influence the way they constructed and resolved problems in their everyday lives. Although these feelings were not directly expressed, they could be inferred from the participants' accounts or behaviour. In the situations that I have described in the preceeding sections, the participants were aware of their feelings of confidence, or lack of it. But there were also situations that I observed, or that the participants described to me, where they appeared not to be aware of their lack of confidence, but it nevertheless seemed to influence the way they constructed and resolved problems in their everyday lives. By definition, the participants did not talk about their implicit feelings and these could not be observed. But I believe that it is possible to infer them. What follows is necessarily my interpretation of what was happening.

I recounted in Sections 5.2.2.2 and 5.2.5.2 that the participants sometimes actively avoided using formal mathematical tools, or using the methods of calculation taught in schools, as Lave (1988) and Nunes et al (1993) found. On these occasions, they chose to use informal tools of various kinds, they estimated rather than calculated, they used informal calculation strategies, or they used intuition to arrive at a suitable resolution of a problem. These choices of action could be for pragmatic reasons: it might be quicker to use informal tools or methods, or the problem might not require an answer with the accuracy that formal tools or methods would provide. But sometimes the methods they used looked very inefficient. On some occasions, I suspect that fear of not knowing how to use a tool, or of failing to do a calculation correctly, that is extreme lack of confidence, might have been the motivation to choose to use informal tools and methods. Only one member of the Everyday Maths Group, Ruth, talked about this fear explicitly (see Section 6.4.1.2). For some of the others, the fear may have been so habitual, and so painful, that it had become implicit. Some of the participants seemed to have developed identities in which they estimated, calculated informally, or used their intuition in many situations and avoided using formal tools and methods, which might cause them emotional pain.

For example, Rhiannon prided herself on being able to find her way around intuitively in a strange place without a map. She said,

> I find I am quite good at orienting myself without (a map). I find I am better when I don't think about it too much. I'm not, I'm not bad at reading maps, but, I kind of have an automatic map, in my head, um, that um, even if I have gone

> quite a complicated way, then I would still have a kind of, more of a feeling than a picture, of where I am really. ... It's kind of like a picture but a very vague picture. And that's why I say it's more like a feeling really, a feeling for direction and which way I've come and spotting landmarks as well and remembering what things looked like at certain stages of the journey. I find that I can go quite a long way in a strange place and still be able to find my way back. ... If I'd come from a café for example, even if I walked for quite a long time and didn't know the area, then I'd probably be able, I find that I'm quite good at finding my way back to the café. And quite, you know, in comparison with other people, I'd say that I was quite good at that really.

Rhiannon expressed great confidence in her ability to find her way without a map. However, when she described finding her way to my house, again without a map, she took a very circuitous route (see Section 5.2.5.2). She was successful at finding her way, but she did not do it very efficiently. Although she said, 'I'm not bad at reading maps', I suspect that she was not very confident about it and therefore avoided it, perhaps without being aware of it. She seemed to have developed an identity as a person who could intuitively find her way and I think she thought that this was a superior skill to map-reading.

In Sections 5.3.2.3 and 5.3.2.4, I discussed the different methods the participants in the Everyday Maths Group used to construct and resolve problems about their income and expenditure. The two participants who managed their money by meticulous calculation may have had implicit feelings of anxiety about overspending and about maintaining their identities as people who were responsible and efficient about money. The four participants who described managing their money intuitively, may have had more implicit anxiety about calculating their income and expenditure than they had about overspending. Ruth said,

> When I do go to the supermarket, I don't normally calculate what I am spending, because I know that if I haven't got enough cash I will just ... put it on my card which is a debit card. ... I do have to have enough money in my account. But I more or less know that I am going to have. And even if I have gone overdrawn a bit, well, I just don't worry about it at all, I don't even think about it really.

6.4.1.2 How levels of confidence varied between situations

The participants' levels of confidence varied a great deal, between situations. Burton says, 'Learners construct themselves and consequently feel differently under different conditions and these feelings are ultimately connected with both the social settings and the learning experience within them.' (2004, pp 357-381) Although the data in my study are not about formal learning, Burton's analysis is still applicable: the participants in my study felt different levels of confidence in different social settings: their confidence was both individually and socially constructed.

Ruth displayed acute anxiety in one situation and great confidence in another. She described a job she had on the till in a sports stadium as 'a nightmare'. The pricing structure was complicated.

> Well sometimes people would want to book the tennis courts and they would want to book them for so long and one person had a pass, so therefore (they were) entitled to a reduction and the other person didn't, so therefore they weren't, plus they wanted to hire a racket and ball. ...

She had to take money from customers, as well as making mental calculations of prices, operate a till and give change.

> And I'm a stage behind them and then trying to work out the change. I do ... the most obvious method which is to say if something came to 18p take 2p and then 10p out. But then I would see the note that I put in front of me that they gave me and I'd think, well they gave me ten (pounds) and I am about to give them three back. By that time I am in a big muddle, you know. I just couldn't do it, because it was money, I think, particularly I couldn't handle it really.

Her confidence in her ability to ring up the correct sum and give the correct change was extremely low.

> I just used to panic, ... I think that I could never decide on methods and I used to skip from one to another and get into a terrible state and they would say they wanted two for the gym or something. For a start I couldn't work it out. I can't do mental arithmetic, full stop. So I'd be struggling trying to do that while they give me the money.

She was accountable for her actions, not only to the customers, but to her managers.

> The till was connected to the computer and every day I used to have to print out everything that was rung up on the till. It was just a nightmare really. ...
>
> I don't know what it was, it was the idea that it was money, the idea that everything you rang up was recorded so that even if I rung up the wrong thing I had to sort of like cancel it or something. I used to hate that.

All three factors described by Buxton (1981) were present in this situation: the potential for feeling personally judged wrong, if she made a mistake in calculation, having to calculate in public and at speed (see also Bibby, 2002). Ruth had two ways of trying to cope with this situation. One was to work co-operatively with another member of staff, who was also very lacking in confidence. They helped each other when they made mistakes.

> Fortunately there was another woman there who had the same sort of problem, so we used to sort of cover for each other in some way. The other person might hover behind the till, while one of us was on it, you know, and see what was going on.

The other way of coping was, 'I don't know really, I kind of went into a trance-like-state I think, I couldn't really tell you,' so that she was no longer aware of what she was ringing up and the change she was giving. She stopped calculating explicitly and worked by hoping she knew implicitly what to do (Tomlinson, 1999).

Ruth also had very little confidence in her ability to learn to use a calculator, when she was presented with one in a previous job and was expected to use it without any training.

> I had to do invoices for payments to contractors and they gave me this calculator and of course I didn't know how to use it. I'd never touched a calculator before, I don't think, you know. So I had to confess I didn't, you know.

She was given a very perfunctory demonstration by a colleague,

> "So here you are", you know, "here's the bill, here's the paper, sit down and put it on there. Here's a calculator." Nothing more. ...And then they thought this was highly amusing, fortunately, you know, that I didn't know how to use a calculator, and they just told me, you know, "Well, you know, just multiply. Here's the multiplication sign, button", you know. They wanted me to add on VAT. So they told me, you know, multiply it like this and they suddenly told me, if you want the total, you multiply it by 115%.

Surprisingly, this demonstration was enough: Ruth found that she was able to use the calculator. She said her reaction to this was to think, 'Wow! You know, this is a revelation to me.' This is probably similar to Burton's (1999) mathematicians when they found a solution to a problem. They were finding new knowledge, and Ruth was finding knowledge that was new to her. This gave her such confidence that she went on to learn to use computers, describing them as very easy to use. Ruth's contrasting experiences with the till and the calculator support the idea that confidence is situation specific, as well as person specific (Burton, 2004).

In Section 6.4.1, I have considered how the participants' levels of confidence in problem-solving in their work or other activities were related to their competence and therefore to their identities as members of communities of practice (Lave and Wenger, 1991) and how they influenced the ways in which the participants constructed and resolved problems. However, there were situations where the participants' confidence was misplaced. Feelings of lack of confidence can be explicit or implicit and can lead participants to use informal tools and methods of calculation. Participants' levels of confidence varied a great deal, between situations. In the following section, I will consider the emotions that influenced the participants' preferences and the choices they made in problem-solving in their everyday activities.

6.4.2 The emotions that influence preferences and their relationship to identity

In this section I argue that the participants in my study often had choices to make about whether to construct problems in their everyday lives, about how to construct them and between different ways of resolving problems. The participants sometimes presented the choices they made as decisions for pragmatic reasons, as I reported in Section 5.3. In other cases they expressed their choices as personal preferences for particular ways of acting or being, that is, they were manifestations of identity. Therefore the decision-making was done on an emotional basis (Damasio, 1996).

6.4.2.1 The upholsterers

In much of the work of the upholsterers, they were following the conventions of their professional practice, as I described in Section 5.2.2.4. But there were still choices to be made about what to do and how to do it. The students had all chosen their own pieces of furniture and there were choices to be made about how to work on them. Some students preferred to re-create the furniture as nearly as possible to the original. Others were adapting pieces of furniture to suit their needs. For example, Evelyn had decided to convert the drop-ended sofa she was working on to one with fixed arms. She was carrying out her preference for one type of sofa over another. Sean, the professional upholsterer, had also developed his own preferred practices. For example, he said he chose to use a particular knot, a double half-hitch, that his mother used for tying parcels, to secure a false button onto a chair, rather than using the conventional reef knot (see Section 6.4.1.1). This was a situation where the knot is temporary: the false button is eventually replaced by a real one. Sean explained that, like a reef knot, a double half hitch would not slip. But it could be tied without having to hold the first half-hitch down with one finger, while tying the second half-hitch, as has to be done with a reef knot. The double half hitch could be tightened easily, but would be much easier to untie than a reef knot. So he always used it in situations where he would need to untie a knot again. Although Sean gave a rational explanation for his choice of knot, the fact that he related the knot to his mother, gives the choice a context of emotion and identity.

6.4.2.2 The gardeners

Similarly, the gardeners followed the conventions of their professional practice, but the gardeners and the customers had their own preferences about the layouts of the individual gardens, about hard landscaping and about plants. Many decisions were made for rational reasons. When I asked Joe who chose the plants for the gardens he was working on, he said that he always lent his customers books of plants to look at, but that they usually left it up to him to choose. He much preferred this, because he could buy what was available at the local nursery, rather than spending time trying to track down particular plants. But choosing plants and arranging them in a garden also gave Joe scope to express his identity as a gardener: to create the kind of garden he preferred. Other decisions were also based on personal preferences. I asked Joe why they had not made a path up the lawn to the deck and the shed at the Yew Tree Road garden (Fig. 5.3). I thought that the owners would get their feet wet, when there was dew or rain on the grass. Again, Joe had a rational explanation: that the slope of the lawn would allow it to drain well. But he also said that he hated lawn paths: an emotional statement. Presumably the owners had not asked for a path, so Joe had exercised his personal preference and had not made one.

After the lawn had been laid at the Yew Tree Road garden, Lee and Joe surveyed the lawn that Lee had laid and Joe suggested to Lee that he should round off the angles on either side of the lawn (Fig. 5.3). Lee demurred, saying that he liked the way they looked as they were. They obviously both had strong preferences, for the way they liked lawns to look and these were related to their identities as particular kinds of gardeners.

6.4.2.3 Members of the Everyday Maths Group

As I reported in Sections 5.2.5.1 and 5.2.5.2, the participants in the Everyday Maths Group varied a great deal in whether they liked to use mathematical tools. Some did use such tools as computers, calculators, measuring tapes and maps, but others actively avoided using them. Ruth was the only one who expressed pleasure in using tools: she said that she enjoyed looking at maps so much, that her friend had suggested that she would prefer to sit and look at a map of the fells than go out walking on them. When on holiday with her partner, he drove and she navigated. 'I do like going to places I haven't been to before. ... I like looking at the map and then going there and finding my way around.' She also said she had a map of London on her wall at home. Ruth described her love of maps as 'anorak-ish'. She was aware that her identity as someone who enjoys maps was open to derision by others, perhaps people who found maps difficult to read. This pleasure in using formal mathematical tools was not expressed by any of the other participants. In many cases they preferred to use informal tools and methods, as I reported in Section 5.2.5.3 and these preferences may sometimes have overlaid implicit feelings of fear of failure in using formal tools, as I discuss below.

The management of time and money involves the construction and resolution of problems, sometimes simple, but very often complex. The participants' feelings about how they constructed and resolved such problems varied considerably. At the second meeting of the Everyday Maths Group, there was a long discussion between the participants about how they solved problems about time in their everyday lives. Of the ten participants present, three said that they were always early for appointments and consequently wasted a lot of time; three others said that they always intended to be on time, but sometimes things happened to them, like losing their keys, which made them late. Claire very forcefully said, 'I hate being early.' She also said that when she invited people to her house she hated them coming early. Jean said, 'I tend to sort of go with the flow and, you know, sometimes I am very early and sometimes I am horribly late.' If she were doing something which could not be abandoned, like baking a cake, then she would finish it, even if that meant that she was going to be late for an appointment. 'When things are cooked, they're cooked, and I have to hang around until they're cooked, you know, I can't leave half-cooked.' These attitudes to the management of time were stated quite forcefully: they were aspects of the participants' identities. For example Jean said,

> It's something to do with how we, what sort of philosophy we have on life, you know, how we organise our lives. ... But there is not a lot, there is not a lot I intend to do about it I suppose, that is what I am saying. It's something that, you know, I accept that is what I am and that is what I do.

These statements of identity were probably influenced by the participants' implicit emotions. The participants who were always too early for their appointments may have been fearing censure by the people they were going to meet, or fearing getting into a state of acute anxiety about being late, or fearing the consequences of missing a train or plane. The participants who were habitually late, whilst intending to be on time, were probably less anxious about the consequences of being late and more anxious about the other things that they had to do. They may also have been trying to avoid the annoyance of hanging around waiting, and feeling that they were wasting time, or the embarrassment of arriving at someone's house early, when the host was not ready to receive guests. Because they were less anxious about the time, they were less organised about the things they needed, like their keys. People who say they 'go with the flow' are suggesting that they are above the petty practical considerations of everyday life, but may, without realising it, be covering up anxiety about not being able to manage their time effectively.

In the third session of the Everyday Maths Group, there was a long discussion about the management of money, that is, about how the participants constructed and resolved problems to ensure that their expenditure did not exceed their incomes. They reported managing their money in very different ways, according to their personal preferences. Two of them said that they kept very strict control over their money. Four others seemed to manage their money by intuition: knowing what their income would cover and spending accordingly. If they overspent on one thing they would cut back on other things. These methods they used to manage their money were, to a certain extent, related to their confidence in doing calculation, as I described in Section 6.4.1.1.1. Where participants lacked confidence in being able to calculate, they tended to prefer budgeting by intuition.

Cathy, who was competent at calculating, described recording every transaction she made with her bank, so that she knew exactly how much money she had, as I reported in Section 5.3.2.3. Ruth, Jean and Vera all had problems with calculation, as I described in Section 6.4.1.1.3. Jean knew that her salary covered her expenditure and did not attempt to make budgets for herself, as I discussed in Section 5.2.2.2. The four participants who managed their money intuitively seemed to be more anxious about doing the calculations, than they were about whether they had enough money. Their identities were of people who were relaxed about money, rather than meticulous, and found calculations unnecessary. Ruth described herself as a 'spoilt child', because calculating what she was spending was anathema to her. She did, however, put the larger household bills on a spreadsheet. But this was so that she could prove to her partner that she was paying her share, rather than to allow her to make a budget. I shall explore this example in more detail in Section 6.4.3. Rhiannon made some attempt to control her expenditure by estimating what she was spending in the supermarket, but said she was reluctant to sit down and work out a budget for herself. She preferred to avoid calculations about how much she was spending. In this section, I have discussed how the participants' preferences and choices influenced the way they constructed and resolved problems. I now turn to considering emotion in social relationships and its relationship to identity.

6.4.3 The impact on problem-solving of emotion and identity in social relationships

In this section I consider how emotion and identity in social relationships influenced the participants' problem-solving in their everyday lives. Social relationships involve mutually negotiated identities as well as emotions (Wenger, 1998). Although the participants were often aware of their emotions, there were some situations in which they seemed not to be aware of them, but, nevertheless, their emotions were influencing the way they acted in social relationships (Evans, 2000).

There were many different kinds of social relationships in the data: between employers and employees, managers and workers, service providers and customers, between colleagues, between a tutor and his students, parents and their children, living partnerships, and friends. The participants expressed or reported on a range of different feelings in their relationships. There was evidence of emotions ranging from mild annoyance to anger, of family pride, love and appreciation of others, and of embarrassment and these also varied in strength from mild to strong. These emotions were sometimes expressed overtly and sometimes revealed in the behaviour of the participants and in the language they used to describe their activities. Some of these feelings influenced the way the participants constructed and resolved problems in their everyday lives.

Ruth told the Everyday Maths Group that in twelve years of living together, she and her partner did not record their household expenditure or make a budget. But she said she was annoyed with her partner, when he teased her by calling her 'a kept woman', because he earned more money than she did. Her annoyance spurred her into creating a spreadsheet of their household bills, not to help them budget their money, but so that she could prove to him that she was substantially contributing to the household expenses. The feelings about her relationship with her partner created a problem, which Ruth solved by working out who spent what on household bills and communicating this to him. As I reported in Section 6.3.2, Ruth hated doing any calculation and she was not interested in working out a budget for herself: she knew that her salary covered her expenditure. But this exercise of putting the household bills onto a spreadsheet was driven by emotion and identity. She was annoyed by, and adamantly rejected, the identity of a 'kept woman', even though she said that it was ascribed jokingly. She was motivated to create the spreadsheet so that she could reclaim her identity in the relationship as a reasonable contributor to household expenses and an equal partner in the relationship.

In other situations, the participants' emotions prompted them into re-estimating a quantity or rescheduling an action. In the following example, Eleanor was recalling her experience of going to swimming training as a child. Her ability to perform a very simple calculating activity, counting lengths swum in a swimming pool, was undermined by her anticipation of an unpleasant emotional experience, of feeling embarrassed at finishing last and keeping everyone else waiting. The trainees were supposed to swim a specific number of lengths of the pool. Eleanor found it difficult having to count very slowly, one number for each length of the pool, and remember how many lengths she had completed. 'So I wouldn't be able to keep count. Otherwise I'd have to count with each stroke and have to be going, "Right, three, three", because I had done three lengths or whatever.' But there was also an affective factor in deciding whether she had swum enough lengths.

> Then everybody else would finish and I would think, "I have only got two to go. Oh, no, I've finished." Because I didn't want, we used to have to wait until everybody had finished swimming. So if somebody was two lengths behind, everyone else would sit on the side shivering, until this person finished. And I thought, you know, "Oh! I hate being that person that keeps everyone else waiting." So I couldn't keep count.

Eleanor's potential feeling of embarrassment, her unwillingness to assume the identity of the person who kept the other trainees waiting, prevented her from being able to keep count. Unlike Buxton's (1981) participants, who were embarrassed about being publicly exposed as not being able to do mathematics, Eleanor was rendered not able to count because she was afraid of the potential embarrassment of being last and keeping everyone else waiting. So she pretended to herself and everybody else, that she had swum more lengths than she actually had.

Communicating a positive identity to other people can be an important aspect of solving financial problems. Joe's relationship with some of his potential customers is an example of this. I went with Joe when he visited prospective customers in Pine Road and Fir Tree Grove, to estimate the cost of work they wanted done. As an experienced gardener, Joe had a wealth of knowledge about how to do a range of gardening tasks, such as putting up fences, laying patios and lawns, and planting and caring for plants. He had a strong identity as a gardener. I suggest that he needed to establish his identity as a competent gardener, to his potential customers, to promote their confidence in him. He needed to convince them that he could do the work efficiently and well, for the price they agreed and that he would be a pleasant and reliable person to have in their house and garden. He appeared to put a lot of time and effort into making this identity visible to the potential customers. He told Mr. and Mrs. Neem at Fir Tree Grove, that he had built the fence round their garden for the previous occupants of the house. I suggest that he told them this because he was proud of his work and it demonstrated to the customers that he could do a good job. When he was quoting an hourly rate for maintaining a garden for Ms. Beech, he told her that he would not 'lean on his spade'. This was a way of saying that he would work hard during the time for which she would be paying a half-daily rate. Joe discussed with the customers the qualities of particular plants: their size, colour, growing habits, medicinal properties and the care they need. He also explained to the customers how he would carry out the work, for example, because a gatepost was wobbly, that he would have to drill down into the ground to secure it firmly. These discussions and explanations enabled him to display his knowledge of gardening work. Joe was very relaxed when he talked to the customers, spent a lot of time talking to them, drank tea with them and played with their children. Joe appeared to have been successful in establishing his identity as a competent gardener and in inducing a feeling of confidence in his expertise, in potential customers. Both estimate visits resulted in him being offered the work. Joe's ability to instill confidence in him in the potential customers was a very important element in solving one of his ongoing fundamental professional problems: obtaining enough work to make a living for himself and to enable him to pay his workers.

6.4.3.1. Implicit feelings of dependency

In the situations, in the upholstery workshop, that I have described in Sections 6.4.1.1.1 and 6.4.1.1.2, the participants were aware of their feelings of confidence, or lack of it. I now suggest that implicit feelings (Evans, 2000) of dependency on Sean, their tutor, had developed in the four upholstery students who were lacking in confidence. Implicit feelings cannot be observed and, by definition, the participants would not have talked about them. Nevertheless, I think it is possible to infer the possibility of their existence from what the participants said or did. What follows is necessarily my interpretation of what was happening.

Feelings of dependency appeared to influence the way that the students and Sean constructed and resolved problems in the workshop. The students had presumably joined the workshop with varying degrees of confidence in their abilities to learn to do upholstery. These levels of confidence would have developed at different rates, according to their different experiences in the workshop, as well as experiences elsewhere. I suggest that one factor in the development of their confidence, or lack of it, was Sean's method of teaching. All the students expressed very positive feelings about Sean. They made a point of telling me how good a teacher he was. Three of them compared their experience of learning in the upholstery workshop with other less favourable experiences they had had of education. But four of the students seemed to have developed implicit feelings of dependency on Sean, which were demonstrated by their inabilities to do anything without instruction, and by their expressions of lack of confidence and of appreciation of Sean. Without discounting the complexity of upholstery practices, it seemed as if Sean's teaching method reinforced his power in the situation and engendered feelings of dependency in some of the students. Their relationships with Sean were as subjects of a benevolent autocrat: as there were no written instructions or diagrams in the workshop, the students had no way of knowing what they should do next, except to wait for Sean to show them. If students asked him what they would be doing next, he told them, 'Wait and see.' (See Section 6.4.1.1.2.) Sequestration of information from newcomers was found by Lave and Wenger (1991) to be a factor in apprentices being unable to learn. The feelings of dependency may also have been exacerbated by the fact that Sean was a male teacher with mainly female students, doing an activity that has been traditionally viewed as masculine. Neither the students nor Sean seemed to be aware of these feelings of dependency that appeared to have developed between them. But I believe that these implicit feelings were factors in the students' lack of confidence. The result was that, even though they had been coming to the class for a number of years, four out of seven of the students said they were incapable of solving problems on their own in the upholstery workshop. They had not progressed past the stage of having to ask for help, sometimes more than once, every time they commenced a new part of the work and they did not consider themselves capable of doing any upholstery on their own. These students' feelings of lack of confidence and their feelings of dependency on Sean seem to be related to their identities. They appeared to have developed identities as upholstery students, rather than as upholsterers. They admired Sean, but were not aspiring to become him.

The significance of the dependence in these relationships raises the question of what education is for. The students may have enrolled in the upholstery class for a wide variety of reasons. Some may have been very committed to learning the subject knowledge. Others may have been more interested in the social aspects of the class, which were well-developed. The students seemed to know each other well. Some of them chatted about their children. One student had brought in plants to give to the others. At Sean's instigation, the students were organising a trip to a stately home to view antique furniture. The students also helped each other with upholstery tasks. The students and Sean all had lunch together at a nearby community centre. This social aspect of the workshop was important: it made a pleasant learning environment and enabled the students to learn collaboratively. Most of Sean's students' motivations were probably to enjoy the society of the class and to re-cover or re-cane pieces of furniture for their own homes or for friends, rather than to take up upholstery as a profession.

But the purpose of adult education is not just to provide students with a social experience, which they could get by joining a club or an interest group, or by going to the pub. It is also to empower them with knowledge and skills, to enable them to develop some autonomy in their chosen subject area (Rogers, 1996). Part of the tutor's job is to develop the students' confidence and abilities to attempt to solve problems without instruction (*Ibid*, 1996). Learning upholstery could either be an experience whereby students not only gain upholstery knowledge and skills, but also develop confidence in their own abilities to learn, or it could be an experience where negative feelings about being able to learn are reinforced and the students feel dependent on the tutor to solve all the problems that they encounter.

In this section I have argued that the participants' emotions about and identity in their social relationships, which were sometimes implicit, influenced the way they constructed and resolved problems in their everyday lives. I now turn to considering whether the participants felt that the solutions that they found to their problems were satisfactory.

6.4.4 Whether solutions to problems were satisfactory to the participants

As I discussed in Section 5.3.1, school maths problems usually have one solution, which the problem-solver is trying to find. It has been worked out by the teacher, textbook or examination paper writer. They decide whether the problem-solver's solution is satisfactory or not: they, not the problem-solver, have ownership of it (Lave, 1988). In everyday life, the problem-solver owns the problem and decides whether or not she has found a solution which is satisfactory to her. As I reported in Sections 5.2.2.2 and 5.2.5.3, the participants used a wide variety of informal tools and methods, to resolve quantitative and spatial problems in their everyday lives. I also described how some participants actively avoided calculation and using formal tools in Section 5.2.5.2. Whatever problem was being solved, the tools and methods that were employed were usually appropriate to the situation and to the degree of accuracy that was required in that particular situation. In Section 5.2.6, I considered whether the participants were satisfied with the solutions that they had constructed to their problems, and found that in many cases they were, for pragmatic reasons. I now discuss the participants' varying satisfaction with the solutions to their problems, which were influenced by emotions and identity.

In Sections 6.4.1.1.1, and 6.4.2, I described Ruth, Jean and Vera, as being very lacking in confidence in their abilities to calculate. In contrast, although Rhiannon also had difficulties with calculation, she had great confidence in her ability to arrive at solutions that were accurate enough for her purposes, using a combination of iteration and intuition. For example, she wanted to work out how many hours she needed to work to earn £150 a week, but she did not interpret this as a straightforward division calculation.

> I asked myself, how many hours a week I need to work, to earn um £150, which is a sufficient amount to get by on, but would leave me free time to do things I want to do. So I did it by saying x hours times £4 is £150. I worked out different values for x. If x is 38 hours, I added up, ... I tried to get £4 into £150. I did lots of workings out on the side. Um ... 4 times 4 = 16: 4 times 40 hours would be 160 ... a very long circuitous way round it.

She worked out that the answer was somewhere around 38 or 40 hours, and this was an accurate enough solution for her, because she would have to find a job and do the hours that were required.

Some of the participants seemed to take pride in finding solutions to problems without recourse to formal tools and exact calculations. There appeared to be a certain cachet in knowing things intuitively. In Section 5.2.2.2, I described Jean's intuitive management of her money, with which she was normally satisfied. She knew that her salary was sufficient to cover her expenditure. What she called her 'financial clock', her intuitive method, only did not work when her employer moved her pay date and this upset her.

In Sections 5.2.5.2 and 6.4.1.1.3, I reported on Rhiannon's method of finding her way to my house without a map, which was successful, but not very efficient. However, she was satisfied with her intuitive method and the result.

> In fact that is something that I enjoy testing myself. It makes me feel really independent, the feeling I can do it. I am always quite kind of, I mean I enjoy that, that is quite a challenge.

Rhiannon actively avoided using maps, possibly because she found them difficult to interpret. But her view of herself as someone who can find her way around intuitively, without the aid of maps, had become part of her identity. Exercising her expertise gave her pleasure.

Jean was a social worker, working with recovering mental health patients. She helped them set up their homes by going shopping with them. Her method of managing her clients' money was very different from the intuitive way she managed her own money, which I described in Section 5.2.2.2. She usually held the clients' money and needed to account to them for their expenditure. So she created a visual tool for understanding what had been spent, rather than using the intuitive method she used with her own money.

> I keep all the bills, which is useful. I'm very methodical about the bills. And what I do is, after we have finished our spending, I, um, list all the bills and, um, pin all the counterfoils to a sheet. ... I do a little list at the bottom of the sheet, and we add it up and I say that you have got *x* number of pounds left over and that's it. ... (I) photocopy that sheet and they get a copy and I get ... the original for my file.

Jean's reason for using this visual tool was not only to make it easy for the clients to understand their expenditure, but to make it satisfactory for herself. 'I can understand. So, if I can understand it, anyone can understand it, you know, because I am not very mathematical.' She was also concerned that the clients knew that she had been honest about their money, 'Just to show that I haven't actually diddled them. ... It's a, I suppose, an honest way really.' She wanted to maintain her identity as an honest person. She said that the clients were quite happy with her way of doing things, so that the problem was resolved satisfactorily both for them and herself.

Jean also described how she worked out her clients' state benefits, by repeated addition.

> Say, for example, if a client's got *x* number of weeks of arrears in Disability Benefit, you, you work out what the benefit is per week, and if it's, say fifteen weeks, I do, sometimes I add three lots of five up ... you know what I mean. ... Add five weeks up and I get the total for five weeks and ... add three totals.

She explained her use of this method by saying, 'So, I'm not very good at division or multiplication.' This sounds as if she was not very happy about the method she used, even if she was satisfied that the answer was correct. But she also made a statement about her identity, 'I'm an addition person, really.'

In Section 6.4.3, I discussed Eleanor's difficulty with keeping count of the lengths of the swimming pool that she had swum and her avoidance of the embarrassment of being last and keeping everyone else waiting. Her resolution of this problem was to pretend to herself and to the rest of the swimming club that she had completed her quota, when she had not. But she did not find that this was a satisfactory solution. She felt that she had not fulfilled her duty, 'I also always had the feeling that I hadn't actually done enough.'

Satisfaction was situation specific: different participants felt differently about different situations. For example, Ruth was skilful with calculators, computers and video-recorders and said that they were so easy to use that anyone could do it. But, as I reported in Section 6.4.1.2, when it came to using a till and exchanging money with customers, she panicked. She coped by going into 'a trance-like state' and working intuitively. But this did not work very well for her. She said, 'I don't know what I did. I got into a mess basically.' However, she felt, perhaps in retrospect, that the management did not really expect her to be able to do the job competently. She had not received any proper training; she had just been shown what to do by another worker, who did not really understand the system either.

> But in a way it was almost expected. It was such a badly paid job, that, you know, everybody who worked on the till had some kind of problems. ... Really, you know, it was like a Scale 2 council job, which is the lowest you can possibly go.

So Ruth's identity in that job, her membership of the community of practice, meant that she did not have to do the work proficiently, but just to get by as well as she could. However, she found the situation extremely uncomfortable. 'That was the worst job I ever had ... it was nightmarish.' So her intuitive solutions to her problems at the till were not satisfactory to her.

In Section 5.3.2.2, I reported Sheda's account of scheduling and re-scheduling her time when she was getting ready to come to the Everyday Maths Group. She re-scheduled what she was doing several times, because of her care for her baby and because her husband, who was going to look after the baby while she was out, did not want to get up. Her first consideration was her baby's health and happiness in deciding what she had to do and how she was going to do it. So although she had made a plan and did not have any difficulty in calculating the time, the solution to the complex problem of getting to the group and keeping her husband and baby happy, was to spend more time than she had planned with the baby, try to persuade her husband to get up, and come to the group late. This was a satisfactory solution for her most important relationships, with her husband and baby, but less satisfactory for her relationships with the group, which caused her some anxiety. Her identity as a mother and wife was stronger than her identity as a member of the group. Her calculation and recalculations about the time enabled her to find the most emotionally satisfactory solution to the problem.

In this section, I have considered what the participants found to be satisfactory solutions, influenced by their emotions and identities. They felt different levels of satisfaction in different situations. In many cases they were satisfied with the answers that they had found, which were sometimes constructed as estimates, sometimes by calculating, and sometimes through intuitive feelings. But there were problems to which they did not manage to find satisfactory solutions. But the participants were the owners of the problems (Lave, 1988) and they decided whether a solution was satisfactory or not. This is very different from school maths problem-solving situations, where there is an external authority who makes the decision

6.5 Summary

In this chapter, I have addressed my third research question (Section 5.1), considering the contribution of the agency of the individual to the construction and resolution of quantitative and spatial problems in everyday life. I found that three attributes of the individual problem-solvers, their previous experiences, their emotions and identities, influenced the way that they constructed and resolved problems. I have modified the model of complex, cyclical, logical problem construction and resolution within socio-cultural contexts, that I developed in Chapter 5 (Fig. 5.1), to include the individual problem-solver with these three attributes, so that it represents my data more accurately (Fig. 6.1). In considering the contribution that the participants' previous experience made to their problem-solving, I discussed my adaptation of Tomlinson's matrix of different ways of knowing, including explicit and implicit emotions in it. The emotions in my data featured varied levels of confidence in problem-solving. These reflected both the participants' levels of competence and their identities in the communities of practice, preferences for particular ways of acting and being and how these also relate to participants' identities, and emotions and identities in social relationships, both explicit and implicit and how these influenced the participants' construction and resolution of problems in their everyday lives and whether they were satisfied with the solutions they found to problems. I discussed how these three attributes of the individual problem-solver make everyday problem-solving different from solving school maths problems. In the next chapter, I consider the implications of my findings for adult numeracy education. I describe an approach to teaching and learning, which uses adults' experiences of everyday problem-solving in the classroom, to make it more meaningful to students.

Chapter 7. The implications of my findings for adult numeracy education

7.1 Introduction

In this chapter, I consider the implications of my findings about problem-solving in everyday life for adult numeracy teaching and learning. My research focussed on problem-solving in everyday life, not maths education. But, through analysing my data and through the work of Lave (1988) and Nunes et al (1993), I became aware of the differences between everyday problems and school maths problems, as I have discussed in Chapters 5 and 6. These are significant, because they relate the research findings back to the origins of the study: the value I put on my understanding, as a teacher, of adult numeracy students' problem-solving activities, in their lives outside the classroom and the relationship of these to their learning of numeracy. But these differences are also significant because they have implications for educational practice, especially in the area of adult numeracy.

Because the participants in my study are adults, the most appropriate comparison for my data is with the maths or numeracy taught in adult education. Since 2001, this has meant the application of the Adult Numeracy Core Curriculum (Basic Skills Agency, 2001), because it is for that provision that funding is available. But as this curriculum is a reduced form of the Mathematics National Curriculum for schools (DfEE and QCA, 1999), many of my observations and conclusions may be apposite to maths education in schools.

First, I examine the tradition in maths education of using everyday contexts in maths problems, including the requirements of the Adult Numeracy Core Curriculum (Basic Skills Agency, 2001) to use the learner's context in teaching. Then, building on the results of the study, I propose a method of teaching and learning adult numeracy, which would validate the methods used by students to construct and resolve problems in their everyday lives and enable them to assess critically their own methods and those of others, including formal mathematical methods. My purpose is to bring educational practice closer to students' familiar practices and, in the process, help them to appreciate the links between the two. It is, I believe, exactly this linkage which has escaped adult learners in the past.

7.2 The use of everyday contexts in maths education

There is a long tradition in maths education of the teacher, text-book writer, or examiner sitting at her desk and making up problems with simulated everyday contexts, wrapped around numerical calculations. (For examples see Cox and Bell (1985), Murray (1986), Heinemann Educational (1991), and Llewellyn and Greer (1996).) The purpose of these problems is partly to give students practice in applying their mathematical knowledge, showing the continuing influence of the Cockcroft Report (DES/WO, 1982) (see Section 2.3.2). It is also to give students opportunities to learn to find a logical progression of calculations, as I discussed in Section 5.3.1.3. Although writers of maths questions do use contexts that occur in everyday life, the problems that they compose are quite unlike the problems that the participants in my study constructed and resolved, as I discussed in Chapter 5 and 6.

In adult numeracy provision, it has been considered to be good practice to collect real materials, such as maps, timetables, utility bills, advertisements, information on Council Tax spending, sports scores from newspapers, tins, packets and bottles of food and household materials and to use these as the contexts of problem-solving (Mace, 1992; Basic Skills Agency, 2001, Marr with Helm, 2002). However, the tendency has still been for the teacher, text-book writer or examiner to construct problems, using these everyday materials, for the students to practice calculation skills, rather than for the students to be discussing how they actually construct and solve problems in their everyday lives. Where learning materials for adult numeracy have been published, they have contained simulations or drawings of real materials, as context for problems designed to practise calculation skills, as in the school maths texts referred to above. (For examples, see Gillespie (1983), Coben and Black (1984), Riley (1990), and DfES (2003).)

7.2.1 The requirement of the Adult Numeracy Core Curriculum to use the learner's context

As I discussed in Chapter 2, the Adult Numeracy Core Curriculum (BSA, 2001) requires that adult numeracy students are taught a list of unrelated mathematical facts and teachers are required to use the contexts which students are expected to bring to the classroom: 'the learner brings the context that will be the ultimate 'proving' ground for their improved skills.' (Basic Skills Agency, 2001, p 8.) The rationale given for this is that it will make the teaching relevant: 'the learner is sure that the skills and knowledge that they are learning are helping them to use their numeracy in the range of ways they want.' (*Ibid*, 2001, p 8.)

Teachers are instructed to use contexts that learners bring, as if it is entirely unproblematic to execute this process. The way that the authors of the curriculum use the term 'context' is a narrow one (*Ibid*, 2001, p 3). They give a list of areas where they say numeracy is used in everyday life: citizen and community; economic activity, including paid and unpaid work; domestic and everyday life; leisure; education and training; using ICT in social roles (*Ibid*, 2000, p 3). They do not take into account the socio-cultural nature of the contexts, or their constituents, the social relationships, the tools, conventions or methods. The authors do not consider the complex, cyclical, logical structures of everyday problems, nor what students bring to situations, their previous experiences, their emotions and identities, and how these impact on problem-solving. They only consider calculation strategies. They do not acknowledge that the transfer of knowledge from students' lives outside of education to the classroom and back again may be problematic (Lave, 1988; Nunes et al, 1993).

The requirement to teach elements of the curriculum using the learner's context is interpreted, in learning materials published by the DfES, as a straightforward matter of making up problems using, as contexts, everyday activities like sport, cooking, making over a garden, and watching television (DfES, 2003). The underlying assumption is that the learning pack writer, knows, presumably by common sense, what problems occur in adult numeracy students' lives, in what contexts, and how they construct and resolve them. Whether or not these problems are appropriate for teaching school mathematics, the assumption should not be made that the solving of such problems will have any bearing on students' solving of the problems that arise in their everyday lives.

If adult numeracy education is intended to support students in their problem-solving outside school, as is proposed in the Adult Numeracy Core Curriculum (Basic Skills Agency, 2001), rather than to teach them school maths, then teachers need to understand the structure of everyday simple, complex, compound, or routine problems and their cyclical, logical, open or closed solutions, within socio-cultural contexts (Fig. 6.1). They also need to appreciate the wide range of informal methods and tools that are used to solve problems in everyday life and to consider the attributes of problem-solvers, their previous experiences, and their emotions and identities, that influence their problem-solving.

In this section, I first considered the traditional practice in maths education of wrapping simulated everyday contexts around calculations to create problems for students to solve. I then discussed the requirements of the Adult Numeracy Core Curriculum to use the learner's context for teaching the elements of the curriculum. I suggested that the authors' interpretation of context was a very narrow one and did not take into account the holistic nature of everyday problem-solving that I found in my study. I concluded that the curriculum is inappropriate to enhance students' problem-solving in their everyday lives, as it claims to intend to do.

7.3 A proposal for a meaningful way of studying problem-solving for adult students

I did not ask the participants in my study about their school experiences, but Ruth volunteered this anecdote in the Everyday Maths Group.

> We were talking ... a group of us got onto talking about our school days and doing logs. And we all remember doing logs and none of us knew what the hell they were. It's amazing, we spent hours, I remember hours pouring over these tables and writing down numbers. And we all remember the same thing and none of us knew what they were. None of us could remember. If we knew at the time, we'd all forgotten it. Basically, we looked up a number and you got another number, didn't you? What you did with that number, and what you did it for, is lost in the mists of time.

Traditional teaching of maths has focussed too much on the processes of computation and too little on the larger picture of the purposes of knowing and using maths (Burton, 1984). In this section, I suggest an alternative method of teaching mathematical problem-solving to adults: to give students the opportunity to describe, discuss and write about the quantitative and spatial problem-solving that they do in their everyday lives, outside of educational establishments, and to appraise critically their and their fellow students' experiences of problem-solving in their lives outside of the classroom and formal mathematical constructions and resolutions.

7.3.1 Ownership of problems and solutions

The participants in the study owned the problems they constructed and resolved in their everyday lives (Lave, 1988). The problems had meaning for them, because they arose in the communities of practice of which they were members, out of their activities, and because the problems had been constructed by themselves, had mainly been resolved to their satisfaction and because the resolution was important to them, practically, emotionally and in terms of their identities. How accurate the answer needed to be, whether the estimation or calculation needed to be completed, whether they used intuition, or informal or formal tools and methods, were matters that the participants decided for themselves. This ownership of problems and their solutions needs to be reproduced, as nearly as possible, in the adult numeracy classroom, if the teaching and learning of numeracy are to have meaning for the students and will support and enhance their problem-solving in their everyday lives. Maths education has traditionally been viewed as a rational and therefore unemotional activity (Lave, 1988; Harris, 1997b). I suggest that it is emotion and identity, which give meaning to problem-solving, and therefore the engagement in problems, in which students have an emotional stake and with which they identify, would transform adult numeracy education.

7.3.2 Collecting students' accounts of problem-solving in everyday life

There is an obvious, but fundamental, difference between adult students and schoolchildren: adults have a wealth of experience of constructing and resolving quantitative and spatial problems in their everyday lives, which children do not yet have. Except for adults with learning disabilities, adult students are usually responsible for feeding themselves and their families and keeping a roof over their heads. They manage their time and money, drive and travel by public transport, practice DIY and gardening and are involved in sports, games and crafts and all the normal activities of adults in our society.

The Adult Numeracy Core Curriculum does not explain to tutors how they can collect information from learners about the contexts in which they use numeracy in their everyday lives. If teachers are really going to use 'the learner's context' (Basic Skills Agency, 2001, p 8), for teaching numeracy to adults, and make their teaching relevant to their students, then they need to gather information about how their students solve problems in their everyday lives, rather than assume that they know this. This calls for a different dynamic in the classroom from the traditional one, with a different relationship between tutor and students. Instead of the teacher being the person with knowledge to impart to the students, she would need to become a facilitator, who enables the students to share the knowledge they have of how they identify, construct and resolve problems. To do this, she will need to listen to the students and to learn from them. Teachers could construct classrooms where students could compare their own experiences of problem construction and resolution with other students' experiences and assess which methods are easiest and which most efficient. Teachers and students could all come to appreciate that different solutions are appropriate in different situations, for different people, at different times.

To meet the demands of the Adult Numeracy Core Curriculum, teachers need to spend time with their students discussing, not only the activities in which they are involved, but what problems they construct and resolve within those activities and how they do this. They need to understand the socio-cultural contexts of these activities: the social relationships, the tools and conventions, whether the tools are formal or informal, and whether informal tools are abstract/cognitive, environmental (concrete or non-concrete), social or personal. Teachers need to know what methods the students employ, whether formal or informal. They need to find out the structure of these problems, whether they are simple, complex or compound, open-ended or closed, routine or unique. They need to know whether there are qualitative as well as quantitative variables and how these affect the construction and resolution of the problem. They need to recognise the logical structure underlying the students' accounts of their problem-solving: how they identify problems, plan their solutions, execute their plans and then review their solutions. They need to know what previous experiences the students bring to the problem. They need to recognise that problem-solving in everyday life is not an emotionally neutral activity: it is affected by levels of confidence, the emotions influencing preferences and choices and the emotions involved in social relationships. They need to be aware that the students' identities are closely related to these emotions. They need to know what the students consider to be satisfactory solutions in different circumstances: how accurate they think it is necessary for answers to be and whether problems are worth the time required to reach a solution.

The assumption in the Adult Numeracy Core Curriculum appears to be that collecting information from learners about the contexts in which they use numeracy in their everyday lives is straightforward. But students are unlikely to disclose their problem-solving activities to tutors, unless they feel relaxed and in a situation where they do not feel judged. For these reasons, as I reported in Chapter 3, I went to some trouble to set up the Everyday Maths Group as a situation in which the participants would feel relaxed, and I promised them that I would not ask them to do any maths, only talk about it. This situation meant that I was able to collect a wealth of stories from the participants. To make a similarly relaxed and safe environment, where students may feel able to describe their experiences outside the classroom, attention must be paid to the students' feelings. Many of the students will feel just as wary of talking about their problem-solving, as some of the participants in, or the non-attenders at, my Everyday Maths Group. It is not possible to promise students that they will not be asked to do any maths in an adult numeracy classroom, where they have come to learn numeracy. But showing a genuine and non-judgemental interest in their activities and the tools and methods they use, which may very well include strategies for avoiding calculation, should help students to feel confident enough to begin to talk about their experiences. As well as promoting students' confidence in constructing and solving problems in their everyday lives, the long-term intention is to help them to analyse their own problem solving so that they can see the relevance of the maths curriculum to what they do.

7.3.3 Reading and discussing accounts of everyday problem-solving

When they are in a maths classroom, students may not find it easy to think about the contexts in which they use maths in their everyday lives. If their experience of learning maths in the past has been of doing pages of calculations using taught algorithms, they may find it difficult to recognise their everyday activities as mathematical (Marr and Helm, 1991). One way of encouraging adult numeracy students to recognise how they construct and resolve quantitative and spatial problems in their everyday lives would be to read with them some of the stories which I have collected in this study. I intend to publish them so that they can be available to adult numeracy tutors and students. The stories could provide a stimulus to students to think about their own experiences and discuss them. Discussion is recognised in the curriculum as a valuable classroom activity:

> Discussion is an important part of developing problem-solving skills. It helps learners to understand different approaches to solving problems, to identify what information is needed, to make decisions about which operations and strategies to use, and to understand how to organise and check results. (BSA, 2001, p 8.)

Discussion also gives students the opportunity to formulate their thoughts into words and sentences: in the process of communicating ideas, students construct, refine and consolidate their mathematical understanding (Clarke, Waywood and Stephens, 1993; Catchcart, Pothier and Vance, 1994; Phillips and Crespo, 1996; Benn, 1997).

7.3.4 Asking students open focused questions

Another method of encouraging students to talk about their experiences outside of the classroom would be to ask them the kind of questions that I asked the participants in the Everyday Maths Group (see Appendix 1). These each focused on one area of everyday life where quantitative or spatial problem-solving may be used, for example the management of time, and asked an open-ended, non-specific, but personal question about the participant's activities. They were printed on cards and handed round the group; no-one was obliged or pressured to answer any particular question. I found that these questions encouraged the participants to give interesting accounts about a wide range of different activities. For example, Sheda replied to the question, 'When you were coming out this morning, how did you decide what time you needed to leave home?', with her story, recounted in Section 5.3.2.2, about calculating the time, whilst coping with the needs of her baby and her husband. If I had asked her closed questions like, 'What time did you leave home?', or 'How long did it take you to get here?', she would probably have replied with a simple numerical answer and I would not have found out how her family relationships and feelings had resulted in her re-structuring her plans several times.

Asking adult numeracy students such questions, in groups where they feel safe to talk about their lives, would probably produce a wealth of stories about different situations in which problems arise, the different ways that they construct them and resolve them. This would then enable students to compare different constructions and methods of resolution and to discuss the relative effectiveness and efficiency of the different strategies used, as well as whether they considered them to be satisfactory in terms of their emotions and identities.

7.3.5 The stimulus of other people's stories

I also found in the Everyday Maths Group that a story told by one participant stimulated others to tell their stories, about similar or connected situations. This enabled me to collect more than one story about some topics and compare the different participants' constructions of problems and solutions and their different feelings and identities in relation to the topic. Examples of this are the two stories, discussed in Sections 5.2.2.3 and 5.3.2.3, that I collected from Jean and Cathy about their management of their personal finances: Jean's intuitive knowing of how much she can afford to spend and Cathy's meticulous recording of every transaction. So adult numeracy students' stories would probably act in the same way: as stimuli to other students to recount their own experiences, problems and methods.

7.3.6 Writing stories about everyday problem-solving

After discussion, students could be invited to write their own accounts of their problem-solving in their lives outside the classroom. This would give students the opportunity to formulate their experiences into written words and thereby construct, refine and consolidate their mathematical understanding (Clarke, Waywood and Stephens, 1993; Catchcart, Pothier and Vance, 1994; Phillips and Crespo, 1996; Benn, 1997; McCormick and Wadlington, 2000). Where students do not have the literacy skills to write their own accounts, or the confidence, they could dictate them into a tape-recorder and they could be transcribed by the tutor, as Tomlin (1999) has done.

An ideal situation for doing this kind of work is where students are learning literacy and numeracy together and time spent on writing an account would address both these skills. Otherwise, some students, with some confidence in their literacy skills, may be willing to write their accounts as homework. Keeping diaries of the learning process, where everyday maths experiences can also be recorded, is another method that has been tried in schools (Borasi and Rose, 1989; Waywood 1992; Clarke, Waywood and Stephens, 1993).

Teachers could collect accounts by students (either written or audio-recorded), instead of textbooks or worksheets with examples constructed by teachers. I would expect that stories collected from students would reveal structures of quantitative and spatial problems and ways of resolving them, that are similar to those I have reported in this thesis: the different levels of complexity, the open-endedness, the logical structure, the routines, the conventions and the idiosyncrasies. Their stories are likely also to indicate the socio-cultural contexts of the problems: not just the activities, but the social relationships, the tools and the methods, the emotions and the identities of the students.

7.3.7 Comparing everyday quantitative and spatial problem-solving with maths problems

Students could then be shown, and be encouraged to discuss, standard mathematical ways of constructing and resolving similar problems: algorithms, formulae, diagrams and graphs.

> In schools, students should be challenged to go beyond their everyday experience, to refine their intuitive understanding, and to express it in new ways. Learning activities in the classroom should provide students with a wider range of situations and tools for use and reflection upon mathematical concepts and relations from different perspectives. It is also the responsibility of schools to engage learners in using a variety of symbolic representations such as written symbols, diagrams, graphs, and explanations. These new representational tools should constitute opportunities for students to establish specific links between situations and concepts that would otherwise remain unrelated. (Schliemann, 1999, p 28.)

While it is important to give students access to school mathematics, it is also important not to undermine the value of their everyday problem-solving skills. They could, therefore, be encouraged to discuss the relative merits of different systems to solve particular problems and be encouraged to develop a critical perspective on their mathematics.

7.3.8 Recognising the logical structure of everyday problem-solving

Polya (1973) and Marr and Helm (2002) recommend teaching students a four-stage process for solving school maths problems, as I discussed in Section 5.3.2. I found that the participants in my study were successfully using a four-stage logical process for solving quantitative and spatial problems in their everyday lives: the identification of the problem, the construction of a plan to solve the problem, the carrying out of the plan, and the review of the result (see Section 5.3). But the participants were probably unaware of using this process and they did not always use it systematically: they sometimes reported the second, third or fourth stage of problem-solving first, before identifying the problem (the first stage) in their accounts of their problem-solving.

It would be useful to discuss with students the process of their problem-solving in everyday life, to identify and recognise the underlying logic of the problem-solving process. But I suggest that this would need to be done using a complex model (Fig. 5.1) that would fit the different structures of various problems and their solutions: the simple routine problems and the compound problems with many contributory sub-problems. A better understanding of everyday problem-solving and its similarity to solving school maths problems in this respect, could empower adult numeracy students in their problem-solving inside and outside of educational establishments.

7.3.9 Recognising the influence of the socio-cultural context in everyday problem-solving

Through discussing their everyday problem-solving, students could also learn about the influence of socio-cultural contexts (Fig. 6.1): how problems are constructed and resolved differently in different activities; how different tools and conventions are used; how they are affected by social relationships. By comparing and contrasting, they would enhance their mathematical understanding. Adult numeracy students could be empowered in their school and everyday problem-solving, through having an understanding of how school maths is a particular community of human practice, with its own history, activities, conventions, tools and social relationships (Lave, 1988), but that it is just one practice amongst many, including their everyday problem-solving.

7.3.10 Recognising the influence of the attributes of the problem-solver in everyday problem-solving

Students could also be helped to understand the influences of their own attributes, previous experiences, emotion and identity, on their problem-solving, both in school maths and their everyday lives (Fig. 6.1). In discussing with students what they consider to be satisfactory solutions to problems in particular situations, they can be asked to reflect on what contributes to making these decisions. In this way, students would be enabled to compare the different levels of satisfaction in different solutions in different situations.

In this section, I have discussed a method by which adult numeracy teachers and students could develop an understanding of everyday problem-solving, using the kinds of questions I used in the study and the stories I have collected as source material and discussing and writing about their own experiences. I have suggested that students' understanding of school maths problem-solving could be enhanced through comparing the construction and resolution of school and everyday maths problems, focussing on the socio-cultural contexts, the logical structures of problems and their solutions and the attributes of the problem-solver.

7.4 Other mathematical work

I am not suggesting that this focus on students' experiences in their everyday lives should be the only teaching approach used with adult numeracy students. I also think that it is important for all adult numeracy students, however low their skills level, to have experience of approaching mathematics in the ways that mathematicians do. Investigations, i.e. undertaking an enquiry the results of which are dependent upon the choices and decisions made by the enquirer and not dictated by the syllabus or text, have not featured strongly in adult numeracy education in this country, although some tutors have done some work in this area. There are a few mentions of simple mathematical investigations in the Adult Numeracy Core Curriculum: the relationship between addition and multiplication, 'calculator investigations' (unspecified) and the tessellation of different shapes of tiles (Basic Skills Agency, 2001, pp 27, 33, 67). Explorations of such topics as magic squares, Pascal's triangle, Fermat's last theorem, triangular numbers, and the Fibonacci series do not require high levels of mathematical skill, are more open investigations and could therefore introduce students to the beauty and exciting nature of maths (Enzenberger, 1998). Such activities can initiate students into the community of practice of mathematics in a way that toiling through worksheets of closed questions does not. 'We also owe our students the opportunity to explore mathematical ideas for their own sake, so the pattern, order and beauty of mathematics can be experienced.' (Marr and Helm, 1991.)

7.5 Assessment

Adult numeracy students are now all assessed at the beginning and end of their courses, using multiple choice school maths questions on computer. The rhetoric of the Adult Numeracy Core Curriculum (Basic Skills Agency, 2001), that numeracy should be taught using the learner's context, seems to be abandoned at this point. As in traditional school maths text-books, tests and examinations, the test questions use circumscribed contexts, deemed by the writer to be representative of students' lives. The problems themselves are simple and closed, having only one correct answer.

By making testing mandatory, the government is promoting the exchange value of the certificate over the use value of education (Lave, 1988), belying the rhetoric of the curriculum, that the purpose of such education is to enable students to solve problems in their everyday lives. In such situations, teachers feel obliged to try to teach students to solve the kinds of traditional school maths problems that they will face in the tests. A more suitable method of assessment would be to use open-ended problems, where students are required to investigate different possibilities and where their endeavours are marked against researched graded answers, such as Brown (1992) developed for schools. The use of such assessment would transform the way adult numeracy is taught.

7.6 Conclusion

In this chapter, I have considered the implications of my findings for adult numeracy education. I have proposed a method of teaching, which uses the students' own experiences as the basis for students and teachers coming to understand how everyday problems and their solutions are constructed and resolved: the socio-cultural contexts, the complex, cyclical logical structures and the attributes of the problem-solver. Students would discuss their own and others' experiences of everyday problem-solving and write accounts of their experiences. From this foundation, students could compare and contrast their experiences with the more formal processes of mathematics. Students should also have opportunities to experience the practice of mathematicians through doing investigations. The assessment of students' skills and knowledge through open-ended topics would be a more appropriate method than through traditional closed school maths questions, as is being done at present.

Chapter 8. Conclusions.

8.1 Introduction

In this chapter, I reiterate the new knowledge that I have found in my data, which I considered in Chapters 5 and 6, in relation to my research questions (see Section 2.6). I describe briefly the model I have developed of problem-solving in everyday life, which I presented in Chapter 6 (Fig. 6.1). I summarise the implications of the findings of my study to adult numeracy education, in particular, a proposal I make in Chapter 7 for students to examine their own and others' problem-solving in everyday life and the similarities to and differences from school maths problems. I then discuss possible research that would develop knowledge of this subject further.

8.2 The new knowledge identified in the study

In this section, I summarise the findings of the study, consider them in relation to my research questions (see Section 2.6) and indicate which of them are new knowledge. This study is built on socio-cultural theories of learning, as developed by Lave (1988), Saxe (1991) and Lave and Wenger (1991). In the study, I focus on the structures of the everyday quantitative and spatial problem-solving of the participants in my study, the tools the participants used to solve problems and the emotions and identities of the problem-solvers. My findings are encapsulated in the model (Fig. 6.1) that I have developed from Saxe's model of culture and cognitive development (Fig. 2.2) and Tomlinson's (1999) model of different kinds of knowledge.

First, as I reported in Chapter 5, I found that the everyday problems were embedded in the socio-cultural activities in which the participants were involved. This accords with the findings of Lave (1988), Saxe (1991), and Lave and Wenger (1991) and begins to answer my first research question (see Section 2.6). There was a wide range of activities represented in the study: many different gardening and upholstery tasks, and diverse activities, at work, at home and during their leisure, reported by the participants of the Everyday Maths Group.

Second, addressing my second research question, I found that the problems had different kinds of structures. Some of the problems were simple, but others were extremely complex, involving a large number of variables, some of which could be qualitative, or compound, having a number of contributory problems, which were sometimes not initially apparent to the participants, when they constructed the original problems. Many of the problems were open-ended: many different solutions to them were possible. These structures of everyday problems have not been identified before. They make the problems very different from traditional school maths problems (Lave, 1988; Nunes et al, 1993), which tend to be simple, have small numbers of variables, none of which are qualitative, have small numbers of contributory problems and be closed, with only one possible solution.

Third, continuing to address my second research question, I found that there was a four-stage cyclical, logical structure to the participants' problem-solving: they identified the problem to be solved, planned a method of solving it, carried out the plan and reviewed the solution they had found (Fig. 5.1). This structure has some similarities with Polya's (1973) and Marr and Helm's methods (2002) of solving maths problems, the constructivist cycle, referred to by Millroy (1992), and with Gal's (1999) four-stage process of problem-solving in everyday life. But the model I have developed allows for greater complexity (Fig. 5.1) and, crucially, includes a stage of identifying the problem, which educational models do not include, presumably because problems are given, ready formed, to students by teachers, rather than being constructed by students. Where the participants' problems were compound, in the sense that there were contributory problems to be solved before the original problem could be resolved, the four stages of the logical structure would be visited a number of times, in a cyclical fashion. Where participants were initially unsuccessful in solving a problem, they sometimes revisited the stages again to make and carry out a different plan. Some of the problems were routine and the participants had routine methods of resolving them (Lave, 1988, Gal, 1999). Some problems had conventions (Saxe, 1991) for their resolution, developed within communities of practice (Lave and Wenger, 1991). Where problems were routine, or involved the following of conventions, the planning and review stages of the four-stage process were not always necessary. The participants found idiosyncratic solutions to other problems, where the community of practice in which they were operating was more loosely structured, such as in their own homes. This has not been reported in other work.

Fourth, the participants often used informal methods and tools to resolve their problems (Lave, 1988; Millroy, 1992; Nunes et al, 1993), as I discussed in Chapter 5, although they did occasionally use formal methods and tools. But there was evidence that they avoided using formal tools, often actively, which has not been documented before. Instead, the participants used informal tools, some of which they invented themselves. I have classified different kinds of informal tools that the participants in my study created, as abstract/cognitive, environmental both concrete and non-concrete, social and personal. Lave (1988) found evidence of participants inventing what I have designated concrete tools for problem-solving and Millroy (1992) found the use of what I have termed environmental tools. The creation of informal tools was one aspect of the impact of the socio-cultural contexts on how problems were constructed and resolved, which addresses my first research question (see Section 2.6).

Fifth, the problems were constructed by the participants and resolved by them: they owned the problems and they decided whether the solutions they had found were satisfactory or not (Lave, 1988). In most cases they were satisfied with their solutions, which could be exact calculations or estimates, depending on the situation, but in some cases, problems were abandoned, as too difficult or too time consuming. These decisions about satisfactoriness were sometimes taken for pragmatic reasons, to do with the situation. In other situations, the influence on the problem-solver was emotional.

Sixth, focusing on my third research question, I demonstrated in Chapter 6 that many of the everyday problems that the participants constructed and resolved also had an emotional context (Evans, 2000) and the participants' emotions influenced how they constructed and resolved problems (Lave, 1998). I found three main categories of the participants' emotions that influenced their construction and resolution of problems: the varying levels of confidence that the participants had in relation to problem-solving; preferences that the participants expressed, which influenced choices that they made in problem-solving; and the diverse emotions that they expressed or revealed about their relationships with other people, which also affected their construction and resolution of problems.

Some of the participants had high levels of confidence in solving problems; others had low levels, which were sometimes as extreme as acute anxiety, fear, or embarrassment. These feelings were occasionally related to calculation (Buxton, 1981; Bibby, 2002), but more often were about the wider contexts of problems. I found that the participants' levels of confidence in particular situations were closely related to their levels of competence in those situations, which equate to the participants' degrees of membership of communities of practice, and therefore to their identities (Wenger, 1998). This relationship between emotion and identities has not been described before. The participants expressed preferences and described how they had made choices, being influenced by emotions and related to their identities. They also described or revealed emotions in their social relationships: annoyance or anger, family pride, appreciation and love, and dependency and the desire for control. These emotions were also related to their identities and influenced how they constructed and resolved problems. Many of these emotions were explicitly expressed by the participants, but I inferred from conversations or their actions that the participants were sometimes experiencing implicit emotions.

Seventh, the participants had previous experiences, what Saxe (1991) refers to as 'prior understandings' (p 17), which influenced how they constructed and resolved problems. What they had learnt from these previous experiences could be classified as practical and theoretical, explicit or implicit (Fig. 6.2) (Tomlinson, 1998). These previous experiences are attributes of the problem-solver rather than the context.

I have constructed an holistic model (Fig. 6.1) which represents the complex, cyclical, logical four-stage problem-solving process, the parameters of socio-cultural contexts in which problem-solving occurs and attributes of the person who constructs and resolves the problem: her or his previous experiences, her or his emotions and her or his identities (Fig. 6.1). This model enables the reader to view holistically all these aspects of problem-solving in everyday life and the relationships between them. Understanding this overall structure and the relationships between the different elements is important to researchers interested in the use of mathematics in everyday life and to professionals concerned with developing adult numeracy provision: teachers, test-writers, managers and policy-makers. I now summarise my key findings and my findings that confirm other researchers' work.

8.2.1 Summary of key findings

The original findings of this study fall into three categories: the structure of everyday problems and their solutions; the tools that the participants used in solving such problems; and the participants' emotions and identities, which influenced the construction and resolution of everyday problems.

8.2.2.1 The structure of everyday problems and solutions

- Everyday problems had different structures:
  - simple: only one or two steps;
  - complex: many variables, qualitative and quantitative;
  - compound: containing contributory problems;
  - open-ended: more than one possible solution.
- The solving of everyday problems conformed to a logical four-stage structure:
  - identifying the problem;
  - planning the method of solving it;
  - carrying out the plan;
  - reviewing the solution.

  (The last three stages share some similarities with, but are not identical to, stages identified by Polya, 1973; Confrey, 1991; Gal, 2000; Marr with Helm, 2002.)

- The solving of everyday problems was cyclical: the different stages of the logical structure were visited numbers of times and in different sequences, according to whether:
  - problems were simple, complex, or compound;
  - problems were routine;
  - the solutions followed conventions;
  - the solutions were idiosyncratic;
  - initial solutions were unsuccessful.

8.2.2.2 Different kinds of tools used in everyday problem-solving

- Formal tools were sometimes used (e.g. tape measures, clocks, calculators).
- Problem-solvers often actively avoided using formal tools, preferring informal tools.

- Different kinds of informal tools were used:
    - abstract cognitive;
    - environmental (concrete or non-concrete);
    - personal;
    - social.
- Informal tools were sometimes created by problem-solvers.

8.2.2.3 Emotions involved in problem-solving and their relationship to identity

- The participants' emotions and identities influenced their problem-solving:
    - the participants had different levels of feelings of confidence, which were related to their competence within practices and to their identities;
    - the participants had feelings of personal preferences, related to their identities, which influenced the choices they make;
    - the participants' emotions within their social relationships, which were related to their identities, influenced their problem-solving.
- Problem-solvers' emotions were implicit or explicit.
- Solutions to everyday problems were usually, but not always, satisfactory to the problem-solver: whether
    - satisfaction occurs for pragmatic reasons;
    - there are emotional causes of satisfaction.

8.2.2 Summary of confirmatory findings

The following findings confirm the work of other researchers.

- The everyday problems in the study were embedded in socio-cultural contexts (Lave, 1988; Lave and Wenger, 1991), with the following parameters:
    - activity structures;
    - social interactions;
    - artefacts and conventions;
    - prior understandings (Saxe, 1991).
- Everyday problems were different from school maths problems (Lave, 1988;

Nunes et al, 1993).

- Ownership of everyday problems by problem-solvers tended to result in satisfaction with solutions (Lave, 1988), whether solutions were
    - complete or incomplete;
    - approximate or exact.
- Emotion influenced how problems were solved (Damasio, 1996; Evans, 2000).
- Previous experiences (Saxe's (1991) prior understandings) influenced how problems were constructed and resolved. They took the form of:
    - knowing practically or theoretically;
    - knowing explicitly or implicitly (Tomlinson, 1999).
- Problem-solving was a logical and cyclical process (Polya, 1973; Confrey, 1991; Gal, 2000; Marr with Helm, 2002).

In this section, I have recapitulated the results of my study in relation to my research questions (Section 2.6) and briefly described the model of everyday problem-solving which I have developed. I now turn to the implications of my findings for adult numeracy education and possibly school maths.

8.3 Implications of the findings of the study for adult numeracy education

A widespread practice in maths education is to attempt to make maths meaningful to students and to test their problem-solving skills by requiring them to solve problems with supposedly everyday contexts. The Adult Numeracy Core Curriculum (Basic Skills Agency, 2001), which is mandatory in adult numeracy education in this country, emphasises using 'the learner's context' for teaching the curriculum units. In Chapters 5 and 6, I have shown that traditional school mathematics problems, which are written within the community of practice of education, but attempt to reflect the world outside the classroom, are very different from the kinds of quantitative and spatial problems the participants in my study constructed, the ways in which they resolved them, and what they considered to be satisfactory answers.

In Chapter 7, I proposed an alternative method for adult numeracy students to learn about problem-solving: to give them opportunities to describe, discuss and write about how they construct and resolve quantitative and spatial problems in their everyday lives. I suggested that students be asked focused open questions, like the ones I used in the Everyday Maths Group (see Appendix 1), to begin the process. In addition, students could read together some of the stories that I collected in this study, which I intend to make available to teachers. The stories could be used as stimuli to help students identify their own experiences of the construction and resolution of problems in their everyday lives. The process of describing, discussing and writing about their own experiences of problem-solving and comparing them with other people's would enable students to recognise their own expertise. This process would require a different dynamic in the classroom: teachers would become facilitators of students recognising and sharing their knowledge of problem-solving in their everyday lives. Teachers and students together would critically compare, in a non-judgemental way, different methods of constructing and resolving everyday maths problems. They could consider what factors contribute to their consideration of a solution being satisfactory or not. Teachers could facilitate learners in recognising the cyclical, logical process of problem-solving, the influences of the socio-cultural contexts of the problems, activities, social relationships, tools and conventions, and the attributes of the problem-solvers, their previous experiences, emotions and identities. Students and tutors together would come to recognise that different tools, different methods and different answers are appropriate to different people in different situations. Tutors could then introduce the more formal mathematical methods of constructing and resolving similar problems, as one practice among many, which could also be subject to critical analysis.

I turn now to considering what further research would develop knowledge of this area of inquiry.

8.4 Indications for future research

My research questions (Section 2.6) were open questions and I did not anticipate being able to reach final and complete answers. Further understanding of problem-solving in everyday life could be developed by testing my model (Fig. 6.1) in other situations: different occupations and with different groups of participants, perhaps adult numeracy students outside educational establishments: at home, at work and at leisure.

In Section 7.3, I proposed a method of teaching adult numeracy, by using the stories that I have collected in this study to stimulate students to recount, discuss and write about their own experiences of quantitative and spatial problem-solving in their everyday lives. This method could be tested by following my proposal, observing the results and interviewing students and their tutors about their experiences of using this method. Their resulting understanding of school maths could be ascertained by a comparison of their performances on the standard tests before and after the study.

8.5 Summary

In this final chapter, I have summarised the findings of my study, in relation to my research questions (Section 2.6), and revisited briefly the model I have developed of problem-solving in everyday life, indicating what is new knowledge. Although the data in this study were wholly collected outside of educational institutions and focussed on everyday life, rather than education, I have considered the implications of my findings for adult numeracy education. I have proposed the use of the stories that I have collected, as stimulus material for facilitating the collection of accounts by teachers, of the students' construction and resolution of quantitative and spatial problems in their everyday lives. These accounts could then be used by students to discuss different ways of constructing and resolving problems, including formal mathematical methods, and what constitute satisfactory solutions in different situations. By this means, students' knowledge would be validated and extended.

Finally, I considered what further research would advance knowledge about the way adults construct and resolve quantitative and spatial problems in their everyday lives.

Bibliography

Acton, C. [2003]. Conversation analysis. In: Miller, R. L. and Brewer, J.D., [Eds.] The A-Z of Social Research. London, Thousand Oaks, New Delhi: Sage Publications: 48-53.

Anderson, J., [1999]. Being Mathematically Educated in the 21st Century: What Should It Mean? In: Hoyles, C., Morgan, C., and Woodhouse, G., [Eds.]. Rethinking the Mathematics Curriculum. London and Philadelphia: Falmer Press: 8-21.

Anderson, J. R., Greeno, J. G., Reder, L. M., & Simon, H. A. [2000]. Perspectives on learning, thinking and activity. Educational Researcher 29(4): 11-13.

Anderson, J. R., Reder, L. M., & Simon, H. A. [1996]. Situated learning and education. Educational Researcher 25(4): 5-11.

Anderson, J. R., Reder, L. M., & Simon, H. A. [1997]. Situated Versus Cognitive Perspectives: Form Versus. Substance. Educational Researcher 26(1): 18-21.

Arthur, C. [1995]. Some remarks on the role and limitations of phenomenology of religion in religious education. Religious Education Vol. 90 No 3/4 Summer/Fall: 445-462.

Atkinson P. and Hammersley M., [1994]. Ethnography and participant observation. In: Denzin, N. K. and Lincoln, Y.S. (Eds.) Handbook of Qualitative Research. Thousand Oaks, London, New Delhi: Sage Publishers Inc., International Educational and Professional Publishers: 248-261.

Basic Skills Agency, [1999]. Literacy, Leaving School and Jobs: the effect of poor basic skills on employment in different age groups. London: BSA.

Basic Skills Agency, [2001]. Adult Numeracy Core Curriculum. London: BSA.

Ball, S. J., [1990]. Self doubt and soft data: social and technical trajectories in ethnographic fieldwork. Qualitative Studies in Education 3(2): 157-171.

Beach, K., [1995]. Activity as a metaphor of sociocultural change and individual development. Educational Researcher 24(2): 285-302.

Benn R. [1997]. Adults count too. Mathematics for empowerment. Leicester: NIACE.

Bibby, T., [2002]. Shame: an emotional response to doing mathematics as an adult and a teacher. British Educational Research Journal Vol. 28: No. 5: 705-721.

Borasi R. and Rose, B. J. [1989]. Journal writing and maths instruction. Educational Studies in Mathematics 20: 347-365.

Brewer, J.D., [2003]. Phenomenology. In Miller, R. L., and Brewer, J. D., (Eds.), The A-

Z of Social Research. London, Thousand Oaks, New Delhi: Sage Publishers: 227-230.

Brown, M., [1993]. Clashing Epistemologies: the Battle for Control of the National Curriculum and its Assessment, Teaching Mathematics and its Applications. The Institute for Mathematics and its Applications: 12(3): 97-112.

Brown, M., [1992] Graded Assessment in Mathematics. UK: Thomas Nelson and Sons Ltd.

Brown, A. and Dowling, P., [1998]. Doing research/reading research: A mode of interrogation for education. London: Falmer Press.

Brown, J. S., Collins, A., & Duguid, P. [1989]. Situated Cognition and the Culture of Learning. Educational Researcher 18(1): 32-42.

Burton, L. [1984]. Mathematical thinking: the struggle for meaning. Journal for Research in Mathematics Education. Vol. 15. No 1.: 35-49.

Burton, L. [1999]. The practices of mathematicians: what do they tell us about coming to know mathematics? Educational Studies in Mathematics, 37: 121-143.

Burton, L. [1999]. Exploring and Reporting upon the Content and Diversity of Mathematicians' Views and Practices. For the Learning of Mathematics, 19: 27-32.

Burton, L. [2001]. Research Mathematicians as Learners – and what mathematics education can learn from them. British Educational Research Journal, Vol. 27, No. 5: 559-599.

Burton, L. [2004]. "Confidence is everything" – Perspectives of teachers and students on learning mathematics. Journal of Mathematics Teacher Education: Vol .7, 4: 357-381.

Burton, L. [2005]. Methodology and methods in Mathematics Education Research: Where is "The Why"? In Goodchild, S. and English, L., Researching mathematics classrooms, A critical examination of methodology. Greenwich, Conn: Information Age Publishers: 1-10.

Buxton, L. [1981]. Do you panic about maths? London: Heinemann.

Bynner, J. and Parsons, S., [1997]. It doesn't get any better. The impact of poor basic skills on the lives of 37 year olds. London: The Basic Skills Agency.

Campbell, B. [2005]. Phenomenology as research method. http://www.staff.vu.edu.au/syed/almvu/papers/bev.html Accessed 1.7.2005.

Campbell, D. T. and Fiske, D., [1959]. Convergent and discriminant validation by the multi-trait multimethod matrix. Psychological Bulletin 56: 81-105.

Capon, N. and Kuhn, D., [1979]. Logical reasoning in the supermarket: adult females' use of a proportional reasoning strategy in an everyday context. Developmental Psychology 15 (4): 450-452.

Carraher. D., Schliemann, A., and Nemirovsky, R., [1995]. Understanding Graphs without Schooling. Hands On!

Catchcart, W. G., Pothier, Y. and Vance, J. H. Learning Mathematics in Elementary and Middle Schools. Scarborough, Ontario: Allyn and Bacon Canada.

Chaiklin, S. and Lave, J., (Eds.) [1993]. Understanding practice, Perspectives on activity and context. Cambridge University Press.

City and East London College, [1991]. Introductory Diagnosis [1]: 4.

Clarke, D. J., Waywood, A., and Stephens, M. [1993]. Probing the Structures of Mathematical Writing. Educational Studies in Mathematics. 25: 235-250.

Cobb, P. [1994]. Constructivism in Mathematics and Science Education. Educational Researcher 23(7): 4.

Cobb, P., & Bowers, J. [1999]. Cognitive and situated learning perspectives in theory and practice. Educational Researcher, 28(2): 4-15.

Coben, D. and Black, S. [1984]. The Numeracy Pack. London, Adult Literacy and Basic Skills Unit.

Coben, D. and Thumpston, G. [1995]. Researching mathematics life histories: a case study, in Mathematics with a human face, Proceedings of ALM-2, Second International Conference of Adults Learning Maths - a Research Forum. London: Goldsmiths College, University of London, in association with ALM: 39-44.

Colwell, D., [1998]. Towards a theory of adults using mathematics: time in everyday life. In Watson, A., (Ed). Situated cognition and the learning of mathematics. UK: Centre for Mathematics Education Research, University of Oxford Department of Educational Studies: 45-58.

Colwell, D., [1999a] An exploration of situated cognition in two professional crafts: upholstery and gardening, in Coben, D. and O'Donoghue, J., Adults Learning Mathematics - 4, Proceedings of ALM-4, the Fourth Internati onal Conference of Adults Learning Mathematics - a Research Forum. Londo n, Goldsmiths College, University of London, in conjunction with ALM:199-209.

Colwell, D., [1999], The roles of feelings and logic and their interaction in the solution of everyday problems. In Mathematics as part of Lifelong Learning, Proceedings of the fifth international conference of Adults Learning Maths - a Research Forum held at Utrecht, The Netherlands ALM-5 1-2-3 July 1998. London: Goldsmiths College, University of London, in association with Adults Learning Maths – A Research Forum (ALM): 103-114.

Colwell, D., [2002]. What Numeracy Skills do Adults need for Life? In Tine Wedege and Lene Johansen, (Eds.) ALM-8 Numeracy for Empowerment and Democracy, the Proceedings of the 8th International Conference of Adults Learning Maths, a Research Forum. Roskilde University in conjunction with ALM: 81-87.

Colwell, D., Duffin, J., and Elliott, S., [1999]. Whose Numeracy? In Mathematics as part of Lifelong Learning, Proceedings of the fifth international conference of Adults Learning Maths - a Research Forum held at Utrecht, The Netherlands ALM-5 1-2-3 July 1998. London: Goldsmiths College, University of London, in association with Adults Learning Maths – A Research Forum (ALM): 132-144.

Confrey, J. [1991]. Learning to listen: a student's understanding of powers of ten. In Glaserfeld, E. von, (Ed). Radical constructivism in mathematics education. Dordrecht, The Netherlands: Kluwer Academic Publishers. Pp 111-138.

Coulon, A., [1995]. Ethnomethodology. Translated from French by Coulon, J. and Katz, J. Qualitative Research Methods, Vol. 36. Thousand Oaks, London, New Delhi: Sage Publications, International and Educational Publishers.

Cox, C. J. and Bell, D. [1985]. Understanding Mathematics 1. Foundation Course. London: John Murray (Publishers) Ltd.

Damasio. A. R., [1996]. Descartes' Error, Emotion, Reason, and the Human Brain, London, Papermac (Macmillan Publishers Ltd).

Department for Education and Employment, [1999]. The working group chaired by Sir Claus Moser, (1999). A Fresh Start - Improving Literacy and Numeracy, Sudbury: DfEE. [The Moser Report.]

Department for Education and Employment, [2000]. Skills for Life. The national strategy for improving adult literacy and numeracy skills. Sudbury: DfEE.

Department for Education and Employment (Autumn, 2002) Testing skills for life. In Update. Issue 5: 10-11.

Department for Education and Employment and Qualifications and Curriculum Authority, [1999]. Mathematics, the National Curriculum for England: Key Stages 1-4. London: DfEE and QCA.

Department for Education and Science, [1959]. 15 to 18, A Report of the Central Advisory Committee for Education (England). London: DES. [The Crowther Report.]

Department for Education and Science/Welsh Office, [1982]. Mathematics Counts: Report of the Committee of Inquiry into the Teaching of Mathematics in Schools. London: Department of Education and Science/Welsh Office. [The Cockcroft Report.]

Department for Education and Science and the Welsh Office. [1989]. Mathematics in the National Curriculum. London: Her Majesty's Stationery Office.

Department for Education and Skills, [2003]. Learner Materials Pack, Numeracy, Level 1, Units 1-6. London: DfES.

Department for Education and Skills, [accessed Sept 2005]. www.move-on.org.uk/testyourskills/ILR_n2/ilr.html

DeVries, R., [1997]. Piaget's Social Theory. Educational Researcher 26(2): 4-17.

Donmoyer, R., [1996], A Focus on Learning. Educational Researcher 25(4): 4.

Enzensberger, H. M., [1998]. The Number Devil. A Mathematical Adventure. London: Grant Publications.

Ernest, P., [1991]. Constructing Mathematics Knowledge. Basingstoke: The Falmer Press.

Ernest, P., [1994]. The Philosophy of Mathematics Education. Basingstoke: The Falmer Press.

Evans, J., [2000], Adults' mathematical thinking and emotions. A study of numerate practices. London: Routledge Falmer.

Fennema, E., [1989] The study of affect and mathematics: A proposed generic model for research. In: McLeod, D.B. and Adams, V.M., (Eds.) Affect and mathematical problem-solving, a new perspective. New York: Spring Verlag: 205-219.

Finch, J., [1984]. 'It's great to have someone to talk to': the ethics and politics of interviewing women. In: Bell, C. and Roberts, H. [Eds.], Social researching.

Politics, problems, practice. London, Boston, Melbourne and Henley: Routledge and Kegan Paul: 70-87.

FitzSimons, G., [2002]. What Counts as Mathematics in Adult and Vocational Education? Numeracy for empowerment and democracy? In: Johansen L. and Wedege, T. (Compilers) Numeracy for Empowerment and Democracy? Proceedings of the 8th International Conference on Adults Learning Mathematics (ALM8) – A Research Forum. Denmark, Centre for Research in Learning Mathematics, Roskilde University, in association with Adults Learning Mathematics – a Research Forum (ALM): 21-32.

Frankenstein, M., [1989]. Relearning Mathematics. A Different Third R – Radical Maths. London: Free Association Books.

French, B., [2005]. The process of research use in nursing. Journal of Advanced Nursing. 49 (2): 125-134.

Friends Centre Brighton, [198-, (exact year unknown)]. From Wages to Windscale: worksheets and how we have used them. London: Adult Literacy and Basic Skills Unit.

Gal, I., [2000]. The Numeracy Challenge. In Gal. I. (Ed.), Adult Numeracy Development, Theory, Research, Practice. Cresskill, New Jersey: Hampton Press, Inc: 9-32.

Galbraith, P. L. and Chant, D. [1990]. Factors shaping community attitudes to mathematics: Implications for future curriculum change. Educational Studies in Mathematics. 21(4): 299-318.

Gardner, H., [1985]. Frames of Mind. London: Paladin Books.

Garfinkel, H, [1968]. Studies in Ethnomethodology. Englewood cliffs, NJ: Prentice-Hall.

Gerdes, P., [January1995]. Ethnomathematics and education in Africa, Institutionen For Internationell Pedagogik, Stockholms Universitet.

Gillespie, J. [1983]. Counting On. Cambridge: National Extension College in association with Channel 4 Television Limited and Yorkshire Television Limited.

von Glasersfeld, E. [1983]. Learning as a constructive activity. In Bergeron, J. and Herscovics, N. Proceedings of the 5th Conference of the North American Chapter of the International Group for the Psychology of Mathematics Education, Montreal, Quebec, PME-NA, 1, pp 41-69.

Gold, R., [1958]. Roles in sociological field observations. Social forces 36: 217-223.

Goodchild, S., [2005], Exploring students' goals in classroom activity. In: Goodchild, S., and English, L., (Eds.) Researching mathematics classrooms, A critical examination of methodology. Greenwhich, Conn: Information Age Publishers: 39-66.

Greeno, J. G., Smith, D. R., and Moore, J. L., [1993]. Transfer of situated learning. In: D. K. Detterman and R. J. Sternberg (Eds.), Transfer on trial: Intelligence, cognition and instruction. Norwood, NJ: Ablex: 99-167.

Greeno, J. G. [1997]. On claims that answer the wrong questions. Educational Researcher 26(1): 5-17.

Greer, A., [1986]. A Complete GCSE Mathematics General Course. Cheltenham: Stanley Thornes [Publishers] Ltd.

van Groenestijn M. [2000]. Assessment Of Adult Students' Mathematical Strategies. In Gal, I., (Ed.) Adult Numeracy Development, Theory, Research, Practice. Cresskill, New Jersey: Hampton Press, Inc: 335-352.

van Groenestijn M. [2001]. Assessment of Maths Skills in ABE: A Challenge. In: Schmitt, M. J. and Safford-Ramus, K. (Compilers), a Conversation Between Researchers and Practitioners, Adults Learning Mathematics - 7, Proceedings of ALM-7, the 7th International Conference of Adults Learning Mathematics – a Research Forum. Cambridge, Mass.: NCSALL and ALM: 66-71.

Gubrium J. F., and Holstein J. A., (Eds.) [2000]. Aging and everyday life. Malden, Mass and Oxford: Blackwell Publishers.

Haacke, F., [2000]. Fun with Mathematics. In: ALM-6, Proceedings of the sixth international conference of Adults Learning Maths - A Research Conference. Nottingham: CEP, University of Nottingham, in association with Adults Learning Maths - A Research Forum (ALM): 4-7.

Hackney Adult Education Institute, [1987-90]. The Take Away Times, Issues 1-6. London: Hackney Adult Education Institute and the Language and Literacy Unit.

Hackney Reading Centre, [1980]. Every birth it comes different. 136 Kingsland High Street, London E8: Centreprise.

Hamilton, M. and Barton, D., [2000]. The International Adult Literacy Survey: What Does It Really Measure? International Review of Education: Vol. 46, No. 5: 377-389.

Harris, M., [1991]. Looking for the Maths in Work. In: Harris, M., [Ed.], Schools, Mathematics and Work. London, New York, Philadelphia: The Falmer Press: 132-144.

Harris, M., [1995]. Finding common threads. In: Coben, D. (Compiler), ALM-1, Proceedings of the Inaugural Conference of Adults Learning Maths, a Research Forum. London: Goldsmiths College, University of London, in conjunction with ALM: 18-23.

Harris, M., [1997a]. Women, mathematics and work. In: Coben, D., (Compiler.) Adults Learning Mathematics - 3, Proceedings of ALM-3, Third International Conference of Adults Learning Maths - a Research Forum. London: Goldsmiths College, University of London, in association with ALM: 1-12.

Harris, M., [1997b]. Common threads, women, mathematics and work. Stoke on Trent: Trentham Books.

Heinemann Educational, [1991]. Heinemann mathematics 7 Textbook. London: Heinemann Educational.

Hendrickson, G. and Schroeder, W. H. [1941]. Transfer of Training in Learning to Hit a Submerged Target, The Journal of Educational Psychology. 32: 205-215.

Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K., Human, P., Murray, H., Olivier, A., Wearne D., [1996]. Problem-solving as a Basis for Reform in Curriculum and Instruction: the Case of Mathematics. Educational Researcher. 25 (4): 12-21.

Hodkinson, P. [2004]. Research as a form of work: expertise, community and methodological objectivity. British Educational Research Journal, Vol. 30, No. 1, February 2004: 9-26.

Hoyles, C., Morgan, C., and Woodhouse, G., [Eds.], [1999]. Introduction. In Hoyles, C., Morgan, C., and Woodhouse, G., Rethinking the Mathematics Curriculum. London and Philadelphia: Falmer Press: 1-3.

Hoyles, C., Noss, R., and Pozzi, S. [1999]. Mathematizing practice. In Hoyles, C., Morgan, C., and Woodhouse, G., Rethinking the Mathematics Curriculum. London and Philadelphia: Falmer Press: 48-62.

Hoyles, C., Wolf, A., Molyneux-Hodgson, S., and Kent, P. (June 2002) Foreword and Executive Summary. In: Mathematical Skills in the Workplace. London: Institute of Education, University of London and Science, Technology and Mathematics Council.

Hutton, B. M., [1998a]. Should nurses carry calculators? In Coben, D. and O'Donoghue J., Adults Learning Mathematics – 4, proceedings of ALM-4, the Fourth International Conference of Adults learning Maths – A Research Forum. London: Goldsmiths College, University of London in association with Adults learning Maths – A Research Forum: 164-172.

Hutton, B. M., [1998b]. Student nurses and mathematics. In Coben, D. and O'Donoghue J., Adults Learning Mathematics – 4, proceedings of ALM-4, the Fourth International Conference of Adults learning Maths – A Research Forum. London: Goldsmiths College, University of London in association with Adults learning Maths – A Research Forum: 192-198.

Hutton, B. M., [1998c]. Do school qualifications predict competency in nursing calculations. Nurse Education Today, 18 (25-31).

Johnston, B., Baynham, M., Kelly, S., Barlow, K., and Marks, G., [1997]. Numeracy in Practice: Effective Pedagogy in Numeracy for Unemployed Young People. Commonwealth of Australia: Australian National Training Authority, Department of Employment, Education, Training and Youth Affairs.

Judd, C. H. [1908]. The relation of special training to intelligence. Educational Review: XXXVI: 28-42.

Kirshner, D., & Whitson, J. A., [1998]. Obstacles to understanding cognition as situated. Educational Researcher: 27(8), 22-28.

Lave, J., [1988]. Cognition in practice: mind, mathematics and culture in everyday life. Cambridge: Cambridge University Press.

Lave, J. and Wenger, E., [1991]. Situated learning, legitimate peripheral participation. Cambridge: Cambridge University Press.

Lerman, S., [2000]. The Social Turn in Mathematics Education Research. In Boaler, J., Multiple Perspectives on Mathematics Teaching and Learning. Westport, Connecticut and London: Ablex: 19-44.

Lincoln, Y.S., and Guba, E.G., [1985]. Naturalistic Inquiry, California, USA, London, UK, and New Delhi, India, Sage Publications Inc.

Llewellyn S. and Greer, A., [1996] [5th Ed]. The Basic Skills. Cheltenham: Stanley Thornes (Publishers) Ltd.

Llorente, J. C., [1997]. Piagetian clinical exploration: work-related activities of building workers with little schooling. In: Coben, D., (Compiler.) Adults Learning

Mathematics - 3, Proceedings of ALM-3, Third International Conference of Adults Learning Maths - a Research Forum. London: Goldsmiths College, University of London, in association with ALM: 38-55.

Luria, A. R., [1979]. The Making of Mind, Cambridge, Massachusetts, Harvard University Press.

Ma, X., and Kishor, N., [1997]. Assessing the relationship between attitudes towards mathematics and achievement in mathematics: a meta-analysis. J. for Research in Mathematics Education: 28, No. 1: 26-47.

Mace, J., [1992]. Talking about Literacy. Principles and Practice of Adult Literacy Education. London and New York: Routledge.

Malmivuori, M. L., [2001]. The Dynamics of Affect, Cognition and Social Environment in the Regulation of Personal Learning processes: the Case of Mathematics. http://ethesis.helsinki./fi/julkaisut/kas/kaava/vk/malmivuori

Marr, B., and Helm, S., [1991]. Breaking the Maths Barrier. A Kit for Building Staff Development Skills in Adult Numeracy. PO Box 9880 Canberra ACT 2601: Department of Employment, Education and Training.

Marr, B., with Helm, S. [2002]. Towards a Holistic Model of Numeracy Competence. In: Johansen L. and Wedege, T. (Compilers.) Numeracy for Empowerment and Democracy? Proceedings of the 8th International Conference on Adults Learning Mathematics (ALM8) – A Research Forum. Denmark: Centre for Research in Learning Mathematics, Roskilde University in association with Adults Learning Mathematics – a Research Forum (ALM): 183-192.

Masingila, J., [1996]. The Mathematics Practice of Carpet Layers: A Closer Look at Problem Solving in Context. Paper presented at the Annual Meeting of the American Educational Research Association, New York, April 1996.

McCormick, K. M. and Wadlington, E. [2000]. Writing about Life: Creating original Maths Projects with Adults. In: Gal, I. (Ed.), Adult Numeracy Development, Theory, Research, Practice. Cresskill, New Jersey: Hampton Press, Inc.: 197-224.

McCormick, R. and James, M., [1983]. Curriculum Evaluation in Schools. Beckenham: Croom Helm.

McDermott, R. P., [1993]. The acquisition of a child by a learning disability. In: Chaiklin, S. and Lave, J. (Eds.) Understanding practice, Perspectives on activity and context. UK: Cambridge University Press: 269-305.

McLeod, D. B., [1994]. Research on affect and mathematics learning in the JRME: 1970 to the present. Journal for Research in Mathematics Education. Vol. 25, No. 6: 637-647.

Millroy, W. L., [1992]. An ethnographic study of the mathematical ideas of a group of carpenters. Journal for research in mathematics education. Monograph. Reston, Virginia, USA: The National Council of Teachers of Mathematics.

Moser, Sir Claus [1999]. Improving Literacy and Numeracy: A Fresh Start. The Report of the Working Group chaired by Sir Claus Moser. Sudbury, Suffolk: DfEE Publications.

Murray, L. [1986]. Progress in Mathematics 4 General. Cheltenham: Stanley Thornes (Publishers) Ltd.

Nolder, R. [1992]. Bringing Teachers to the Centre of the Stage: A Study of Secondary Teachers' Responses to Curriculum Change in Mathematics. Unpublished PhD thesis, London, University of London.

Noss, R., [1990]. The National Curriculum and Mathematics: A Case of Divide and Rule? In: Dowling, P. and Noss, R., (Eds.) Mathematics *versus* the National Curriculum. Basingstoke: The Falmer Press: 13-32.

Nunes, T., Schliemann, A. D, Carraher, D. W., [1993]. Street mathematics and school mathematics. UK: Cambridge University Press.

OECD, [1997]. Literacy Skills for the Knowledge Society. Paris: OECD

Piaget, J. [1952]. Jean Piaget. In Boring, E. G. et al (Eds.), History of Psychology in Autobiography Vol. IV, Worcester, Mass. Clark University Press, pp 237-256.

Phillips, E. and Crespo, S., [1996]. Developing Written Communication in Mathematics through Math Penpal Letters . For the Learning of Mathematics. 16, 1: 15-22.

Polya, G. [1973]. How To Solve It. A New Aspect of Mathematical Method. Princeton, New Jersey: Princeton University Press.

Qualifications and Curriculum Agency. [2000]. National standards for adult numeracy and literacy. London: QCA.

Riley, T. [1990]. A Way with Numbers. London: BBC.

Rogers, A. [1996]. Teaching adults. Buckingham and Philadelphia: Open University Press.

Saxe, G. B., [1991]. Culture and cognitive development - studies in mathematical understanding. Hillsdale, New Jersey, Hove, and London: Lawrence Erlbaum Associates.

Schliemann, A. D., [1999]. Everyday Mathematics and Adult Mathematics Education. In: Mathematics as part of Lifelong Learning, Proceedings of the fifth international conference of Adults Learning Maths - a Research Forum held at Utrecht, The Netherlands ALM-5 1-2-3 July 1998. London: Goldsmiths College, University of London, in association with Adults Learning Maths – A Research Forum (ALM): 20-31.

Schwab, I and Stone, J., [1985]. Language, Writing and Publishing, Work with Afro-Caribbean Students. London: Hackney Reading Centre – City and East London College.

Sewell, B., [1981]. The use of mathematics by adults in daily life. UK: ACACE.

Sfard, A., [1998]. On two metaphors for learning and the dangers of choosing just one. Educational researcher: 27(2), 4-13.

Skemp, R. R., [1971]. The psychology of learning mathematics. Harmondworth, UK: Penguin.

Stanage, S. M., [1987]. Adult education and phenomenological research. New directions for theory, practice and research. Malabar, Florida: Robert Krieger Publishing Co, Inc.

Tomlin, A., [1999]. A 'democratic classroom', but who speaks loudest? Research with basic mathematics students. In: Mathematics as Part of Lifelong Learning, Proceedings of the fifth international conference of Adults Learning Maths - a Research Forum held at Utrecht, The Netherlands ALM-5 1-2-3 July 1998. London: Goldsmiths College, University of London, in association with Adults Learning Maths – A Research Forum (ALM): 20-31.

Tomlin, A., [2002]. 'Real life' in everyday and academic maths. In: Ostergaard L. and Wedege, T. (Compilers.) Numeracy for Empowerment and Democracy? Proceedings of the 8th International Conference on Adults Learning Mathematics - a Research Forum, held at Roskilde University, Denmark 28-30 June 2001. Centre for Research in Learning Mathematics, in association with Adults Learning Maths – A Research Forum: 156-164.

Tomlinson, P., [1999]. Conscious Reflection and Implicit Learning: Towards a balance in teacher preparation. Oxford Review of Education: Vol. 25, No. 3: 405-424.

Tout, D., [1995]. Some lessons learnt. In: D. Riordan and D. Tout, (Eds.) Numeracy in focus. Australia: Adult Literacy Information Office, New South Wales and Adult Basic Education Resource and Information Service, Victoria: 10-15.

Vygotsky, L.S., [1986]. [Ninth printing 1996.] Thought and language. Translated, newly revised and edited by Kozulin, A. Cambridge, Mass: The MIT Press.

Vygotsky, L.S., [1978]. Mind in society – The Development of Higher Psychological Processes. Edited by Cole, M., John-Steiner, V., Scribner, S. and Souberman, E. Cambridge, Mass.: Harvard University Press.

Waywood, A., [1992]. Journal writing and learning mathematics. For the learning of mathematics. 2: 34-43.

Wenger, E., [1998]. Communities of practice, learning, meaning and identity. UK: Cambridge University Press.

Wicks, M., MP, [2001]. Foreword to Adult Numeracy Core Curriculum. London: The Basic Skills Agency: *v*.

Wragg, T. [Sept 13th, 2005]. Marking market makes a mockery. London: Education Guardian: 4.

Appendix I. Everyday maths group - list of prepared questions

1. Last time you went shopping for food, how did you know whether you had enough money to pay for what you had in your trolley or basket?

2. Can you remember a time when you were deciding if you had enough to buy something you wanted? How did you do it?

3. Can you remember when you were in another country, how you worked out how expensive things were?

4. When you were coming out today, how did you decide what time you had to leave home?

5. Can you remember an occasion when you needed to decide if you had time to do something? How did you work it out? How do you think about time?

6. Can you remember a time when you needed to work out a rota or a timetable for a group of people to do things?
   How did you do it?

7. Can you remember working out how long ago something happened?
   How did you do it? How do you think about past time?

8. Can you remember working out when someone was born, from knowing how old they are? How did you do it? How do you think about dates?

9. Do you plan what you are going to watch on television? How do you do it?

10. Can you remember a time when you wanted to record a programme on television? How did you decide if you had enough video-tape for the programme?

11. How do you remember your way to somewhere you have been before?

12. Can you remember a time when you needed to work out how to get to a place you haven't been to before? How did you do it? Were you successful?

13. Last time you used the Underground, how did you find your way around?

14. Can you remember a time when you needed to work out the distance between places on a map? How did you do it?

15. Can you remember a time when you needed to work out which direction to go in from a map? How did you do it?

16. When you are cooking, how do you decide what quantities to use?
Can you remember an occasion when you were cooking for more than the usual number of people? How did you work out the quantities?

17. Can you remember a time when you were thinking of buying some furniture? How did you work out whether it would fit in your home?

18. Can you remember a time when you were planning where to put things in your garden? How did you do it?

19. Can you remember when you were planning to make something by knitting, sewing, woodwork, or pottery or some other craft? How did you work out what

materials you needed?

20. Can you remember planning to do your own decorating?
How did you work out what materials you would need?

21. Can you remember telephone numbers? How do you remember them?

Appendix 2. Transcript of 2nd meeting of Everyday Maths Group - 8.6.97

Present: Claire, Cathy, Eileen, Eleanor, Jean, Meera, Rhiannon, Ruth, Sheda, Shelly

Side 2a *(5 mins from beginning of tape.)*

D. Would you all like to say hello in turn?

All. Hello . . . *laughing)*

D. Who wants to begin then and talk about their life? *(people laugh)*

Elea This morning J. and I were talking about when we get our mortgage. Who's going to be contributing the most to it. He earns twice as much as I do. I'm trying to work it out in my head how much, what kind of percentage my contribution is and couldn't do it. Cause I was trying to do it in my head and first of all I thought oh well I'm earning half of him and half the mortgage and then I thought no I'm not. Perhaps I'm paying quarter of it and perhaps I'm paying a third and I couldn't set up the calculation. (laughs). J. just laughed at me because I couldn't do it. (laughs) He just laughed at me because I couldn't do it.

Rhia It's two thirds and one third.

D. Can you sort of justify that?

Rhia If he is earning twice as much you can separate the mortgage into three parts. J. pays two parts and you pay one part.

Ruth You like it anyway.

D. Didn't you do this calculation when you were paying rent?

Elea No I am not sure why, no. We were just idly thinking about it. *(Laughs)*

D. Anyone else, or does anyone else have that kind of problem sharing? Or does anyone else want to talk about anything else? What did you come up with when you were talking to each other?

Rhia I had to figure out my finances. . . I'm not sure if it was all correct or not. It's very messy there. How much time a certain amount of hours . . . fifty pounds. . . such and such hours . . . x amount of hours. I could work between six and nine hours.

D. Right.

Rhia So, you have to work out the average

D. Did you do it on paper?

Rhia I did do it on paper. I had a go

D. What about you?

Cath We didn't use much maths. We only did . . . an amount of money into the Fleagh. So we knew that when we were there was no reason that we had not to spend more than that money for the whole twelve hours or however long we were there. It was sort of can I afford a tee shirt or do I want three portions of chips? *(Laughs)*

D. What did you end up buying in the end?

Cath We didn't spend all that much. I did end up buying a tee-shirt in the end. I couldn't spend about £25.00 on food in a day even if I wanted to. So it was not very difficult maths but calculating how much were the prices in there working out that even if you had ten . . . you would have enough money.

Elea You didn't end up at the end of the day being really thirsty or something.

Cath No no we had money left over.

D. Did you take a limited amount of money because that was what you had available?

Cath It was because I didn't want to spend any more than that. If there were things there plus the fact that I didn't want to take any more In case it was stolen, shove your money in your pocket and know that it was there and there was nothing else to worry about. Even if I had taken credit cards in I wouldn't have wanted to spend any money on it. And then I would be regretting it in a month when I didn't have that money then. . . . calculation.

D. Can you be more specific about when you were talking about your chips and your tee-shirt?

Eile The chips were £1.50 for a minute portion. The tee-shirt was £14.00 and I bought that fairly soon because I didn't want them to run out.
We weren't sure then whether we would be buying anything else. I think taking £30.00 in . . . the tee-shirt, there is only going to be £17.00 left to last the whole 12 hours. It might sound a lot of money but it's because I don't have access to any more. We want to make sure we don't spend it.

Elea It sounds as if things were really expensive. *(Yes - together)*

Eile A bottle of water, that would be 50p out

Cath . . . taking it all in

D. Really, they don't allow you to take it in?

Cath No.

D. Well thanks, what about you Eileen?

Eile Mine is pretty similar to Cath's. I've done stuff similar to Rhiannon's as well. My finances because I signed up with the agency how many hours I had to work at weekends and how long . . .

D. Did you do it all written down?

Eile No it was sort of in my head roughly. I get ten pounds an hour. How many hours did I need to work? It is a bit similar to Rhiannon's really.

D. So you've got to work out how many hours a week.

Eile How many hours a month, I worked it out on a monthly basis. If I did a test match which is five days, I got five hundred pounds for that and I didn't have to do anything else. . . one days work I would have to find something else.

D. Do you have a very clear idea of how much it costs you to live?

Eile Mm because I get a monthly allowance from my parents, I have always got it worked out that I can survive on that much money per week that is. I know how much my shopping is when I go to Tesco.

D. Are you very strict with yourself?

Eile Not as strike as I should be. I do try to be, before I go anywhere I try to work it out. And it just goes over. I go around Tesco's I meant to spend ten but I have really spent twelve. When I get to the check out I add it up in my head.

D. So do you then put some things back or ?

Eile No but then the next week I have to ration myself a bit more. If I buy ice-cream and chocolate one week then the next week I buy pasta.

D. *laughs*

Jean . . . beans on toast

D. Thanks

Mera I am trying to organise a trip to go away to India, so yesterday I had to sort out a sum of money from . . . and I'm going with someone else so I am trying to work out how much the visa costs and injections and everything and deduct that from the money I've got and I was trying to work out how much, estimate how much the whole thing should cost and um trying to plan my time. There's a certain amount of places I'd like to go to and how many weeks I want to spend in each kind of days and when I get there you know, how much I'll be living on each day. I was trying to do that yesterday as well.

D. How did you do it, did you write it all down?

Mera Mm yes, no, by deducting it from how much I've got, so twenty roughly estimates how much I've got. Spending money left over. So I had to work out, go to the bank, find out how many rupees there were to the pound.

D. Oh right, how many rupees are there to the pound?

Mera I think there are about 18?

D. So do you know the prices of things in India?

Mera Roughly, yes roughly . . .

D. From when you've been before.

Mera Mm

D. Do you know how much railway journeys cost? And how much food is likely to be . . .

Mera Yes I've got rough estimates. I was trying to do that yesterday as well. I was trying to work out how much I'd need for living each day. I was trying to stick to the budget. I was trying to work out . . . with it being so far away and I am going to be there for about six weeks. I am trying to work out how you do that and like if I need travellers cheques. And how much change . . .

D. Right

Mera That is it then

D. When you say you haven't been so far away before do you mean ?

Mera I have been away but I haven't been like out of Europe without my parents. So well my mum is going to come for two weeks then we'll be pretty much left to our own devices . . .

D. What you and her or are you going to separate?

Mera No I am going to go with my sister as well. My mum is coming for the first two weeks.

D. Mm

Mera Mm

D. Right we are just thinking about what maths we've used in the last 24 hours. This is Rhiannon and . . . and Eileen and Meera and this is Sheda. You know Ruth.

Shda I'm sorry I'm late

D. That's OK.

Shda I found the bus centre . . .

D. You're not last because Clare and Shelley have rung up to say they are on their way ...

D. I've got some questions here. I'll just sort of hand them around but if you don't like the questions you've got take another one. *(People laugh.)*

Shda I don't like the one I've got.

D. Rhiannon did you work out your?

Rhia Yeah, I'm trying to work out how I did it. I asked myself how many hours a week I need to work to earn um a £150.00. Which is a sufficient amount to get by on but would leave me free time to do things I want to do. So I did it by saying x hours times £4.00 is a £150.00. I worked out different values of x. If x is 38 hours. I added up . . .

D. So you put in lots of different x's.

Rhia I tried to get £4.00 into £150.00. I did lots of workings out on the side. Um . . . 4 x 4 =16; 4 x 40 hr's would be 160 . . . a very long circuitous way around it.

D. It sounds like quite a sensible way to me. Do other people do that when they are working out something?

Jean Similar.

D. Do you understand what Rhiannon said?

Jean Do you pay any tax on that?

Rhia No I am not paying any tax.

D. Because you're a student?

Rhia Because I am a student. And also because of the place where I am working.

Jean You can earn a certain amount. If you earn over a certain amount you calculate whether you earn over a certain amount.

Rhia Yeah but it is something like over £4 or £5,000 a year because this is only a summer job and . . . I did actually do the calculation. The highest possible amount of money I could earn. If I went all out and worked about 10 hours . . . and that is highly unlikely that I would do that.

D. *Laughs* - and what is this down here?

Rhia That's the amount of hours . . . because the first job that I have is a fixed amount of hours. 25, that is quite a low wage and that would be . . . and the other job . . . I guess I would be doing between 6 & 9 hours every week. Plus I worked out a rough estimation of two scenarios . . . scenario . . . I hope to be between £111.50 per week and . . . which isn't really an awful lot but it gives me a lot of free time which I value . . .

D. If you don't like . . . if you don't like the question you have got, you can pass it on.

All. *Laugh.*

Jean Counting sheep, that's the only thing in maths I use to calculate *(laughs)*

D. *Laughs.*

Rhia A part time job as a shepherdess

All. *Laugh.*

D. If you don't like the question you have got you can help yourself to one of these . . *(Bell rings.)*

Elea Do you want me to get it?

D. No, I'll get it, you think about your question. I might as well switch these off.

...

Ruth I've got a question about buying furniture and thinking about how it will fit in. It just reminded me that when we were in the open learning centre the first week we had these parts of a desk that we had to fit together. Which combined open learning and library desks. One of the powers that be came down and said no she didn't like that. And therefore we had to make it into two desks. And I was really impressed: one of the library assistants got out these big sheets of paper and made it into a desk so that we could sort of move them around. So I thought of doing that when it came to buying our own furniture. And then of course it didn't really work but where my partner works there is a big printers with these big relays and these big round pieces of cardboard. I got him to bring some of those home. So we sort of sat and pretended that was a table, sort of trying to decide whether that table would be big enough and we had some bits of brown paper from where the settee would be. We had a completely empty front room and nothing to put in it. We had to buy furniture. So on the other hand we got these pieces of paper. We ended up having to measure things, which is what I was really trying to avoid. I have a bit of a problem with numbers.

D. Did you sort of measure them and make the paper and the cardboard to scale?

Ruth No not really, we measured, we saw a settee, we measured it and then we came back and measured it against the piece of paper that we had on the floor and compared it to the size of the thing that was there really.

D. So you were using a piece of paper that was the full size of the things that was . . .

Ruth Yes

D. You marked it off on the piece of paper that was the full size of the settee.

Ruth Mm in a way, once we had done it, it didn't look right where it was anyway. We ended up doing something completely different.

D. *Laughs*

Ruth	We still haven't got a table that is any good . . . second hand. Basically I thought that was a really good idea about trying to get these bits you could use instead. But unfortunately it didn't really work out.
D.	*Laughs.* Has any one else done anything like that? Buying furniture in . . . thinking of buying furniture and deciding how it would fit .
Cath	Thinking of buying furniture, when I was young I've got in my room a space that is very small. I had a space beside the bed which is a very specific space so I had to go and look for furniture that was that size and that size only. And there was another section beside the wardrobe. I've got one of those TV things. It had to be one of those because it was a space of a foot wide or less than a foot wide. I've actually bought things because I know that furniture of another size isn't going to fit in there.
D.	And how did you measure the space?
Cath	With a tape measure really. *(Laughs.)*
D.	One of those steel ones?
Cath	Yes
D.	Do you use a steel tape?
Ruth	Yes, it's amazing how standard everything is once you start looking. The pillows that came with the settee, the cushions rather. I didn't like them, I wanted to get some more cushion covers. And everywhere I went the cushion covers were always the cushions rather, were always the wrong size. I've still got the ones I don't like.
All.	*Laugh.*
Ruth	You just get sick of it in the end. Everything seems to be you know when you start going out and start measuring things you find that everything is to a pattern really . . .
Jean	We found that about 5 or 6 years ago. Completely rearranged out kitchen. Because I am small I like all the surfaces and benches quite to my height and cupboards have to be lowered and it gets and to get equipment to fit under benches is really hard. If you're not a standard height and I think the standard height is about 5ft 3, so if you are under 5ft 3, you want something that sort of fits your body height. It's um a problem.
D.	So did you go around the shops with a tape measure?
Jean	No I think we did it by height measuring it against the height really. My body height.
D.	Right so you knew where the bench came so far on your body? And then when you were in the shop you measured it like that.
Jean	And eventually we worked out that the equipment we needed was so many cms and it is surprising how little they, everything is standard.
D.	Yes. Shelley, you were telling me that you always carry a tape measure in your handbag.
Shlly	*Laughs.* Yes, because I often, you know change furniture from one side and another. I don't like that way there, so I keep changing it.
D.	You move it around in the room?
Shlly	Yes that's right. So I have a tape measure, always I carry this one with me.
D.	Oh, it's lovely and bright. So if you see something in a shop you like, do you
Shlly	Yes
D.	and do you know the sizes of your rooms?
Shlly	Yeah, oh roughly

END OF SIDE 2A

Shlly	Go home, measure the space and then come back and decide.
D	And would you go back to the shop. You don't carry all these measurements around in your head.

Shlly No, I have to write it down. I can't remember.

D Anybody else?

Shlly I learned it from previous experience actually. I had a very small house before and I got a bunk bed when my children were young and the bunk bed was bigger than the space I had.

D What did you do then.

Shlly Then I had to change it, you know.

D Back to the shop.

Shlly That's right, so I went to a lot of trouble and I learned from that experience. That is why I always carry a tape measure around.

Shda Because I wanted to fix a bookcase, buy the material and nail it on the wall but I am not sure how to do it . I don't know the way that it will fit the space I have, although my husband measured one morning and it still, I am not sure whether it will fit. When I go to the shop if the ... I don't see the clear picture of how big it will be.

D And in the shop, are the pieces labelled as to how big they are.

Shda No, only the price and sometimes they are bigger and you have to cut it yourself.

D Right!

Shda That's when I think I will need Dhamma's help. Yes! Oh! I'm hopeless. I have to find someone who will say "that's the size you will need and

D Right!

Shda Because it is the first time I am measuring the house and never done it before.

D So in places where you have lived before then how do you sort of ...

Shda You don't worry about the space, you know the space, you buy things, you don't worry about whether they will fit and then ... like you. You don't worry about the space.

D So you haven't had Shelley's experience of buying something and having to send it back to the shop.

Shda No.

D Are people's rooms tend to be bigger there than they are here.

Shda Ah! Yes! Also you don't have, sometimes you buy your own bed, cupboards, one or two and that's it.

D But what do people sit on.

Shda There is also a lot of room for sitting. So sometimes cushions on the floor, Arabian Settee.

D The Arabian Settee, what is that..

Shda It is a cushion on the floor, mattress on the floor.

D Right. So they just put on the floor.

D Anybody else.

Shda People tend to have this type of seating in Bangladesh as well, before, but now the lifestyle has changed. People tend to buy more furniture. And traditional seating arrangements.

D So when you lived in Bangladesh did you use these?

Shlly No, but in my childhood I saw in my grandparents home there were big, people used them as beds as well, just wooden table, a big one. You can sit on it, you can lie on it in the evening, so you just keep one in your home and designed for whenever ever you need it. If you have guests coming you put down cushions on top of it. In the evening take everything away and you can lie on it with your mattress and lie on it.

D Ah. Right, so it is very versatile .

Shlly Versatile.

D So where would you store the mattress during the day.

Shlly They must have some space somewhere in the loft or somewhere in the backroom, or underneath that one. There is a big space underneath there.

D Right!

D So how high is it off the ground.

Shlly It's about, if you ask me measurements.

D No just show me on

Shlly Three feet!

D So she is holding her hand

Shlly Yes, about three feet from the ground.

D So she is holding her hand three feet from the ground.

Shda That's the problem I have, I have no ... of measurement, you know. It's just. Now I have to learn. I have to buy measure tape and I have to see how ...

D Did you use feet. and inches in Somalia.

Shda Ah! I think it was millimetre.

D Ah! Right!

Shda I know 2 metres

D She is stretching out to the side and holding her other hand to her chin.

Shda And when I am buying one piece of cloth on the shoulder, we call that the side. It is always two metres. ... twice and then I hold with the other. Sometimes you have to check yourself before you buy it when it's the right size.

D So this piece of cloth, how do you use it.

Shda You do it on the shoulder, its a kind of scarf.

D Right. So she is indicating wrapping it around her body and crossover at the front and one piece throwing over the shoulder. I am having to say this for the tape because I won't remember it.

Shda So that's the only size, you know I can see. But when its inch and feet I have no idea. I have to use a ruler.

Shlly People used to ... and have eighteen inches, I have sixteen inches though.

D What did you call it.

Shlly I said it, suppose one yard. If you want to buy one yard of material its two. You don't have any tape measure. You don't carry tape measure like me in olden days. You just measure, I've got sixteen, just bear it in mind. But still that hand has got eighteen inches, that means half a yard.

Shda It's man measurements.

Shlly Yes, it's man measurements, eighteen inches You don't need a tape measure. Two hands is one yard.

D Right, so she is holding the cloth to her elbow and then to her fingertips.

Shlly The middle finger, yes.

D Middle finger, and then she did it again to get the whole yard.

Shda ... that measurement. Even nowadays

Cath That's how measurement started isn't it. Or how people used to do it, you know horses were measured in

Shlly Some people have to measure six inches from this point, from the thumb to the middle finger, six inches. Some people have ... the measurement. Some people just measure like this.

D That one is a metric one (ruler), I'm afraid.

Shlly Let me see..... Seven.

Shda No, In Somalia that's the way people measure even today. They use the ...

D And what do you call it.

Shlly You call this biba. And that one taco.

D Taco?

Shlly ... and one ... three ...

D What would you measure with this, cloth.

Shlly Cloth, yes. Also when you are making mats.

D Oh! All right

Shlly We are making weaving, yes.

D Yes.

D And what would you use this for.

Shlly This one.

D Yes.

Shlly For example, you are measuring a piece of cloth and you say it is two, for example, two ... and one ...

D Ah! right,

Shlly So it is smaller, smaller.

D And do you ... as well, that measurement.

Shlly Yes.

D What do you call it then.

Shlly Ah! What do you call it, you call it hand, two hands.

D That's from the fingertips to the elbow.

Shlly Yes, I forget that term for this

D And do you use it in the same way as ... that if you were measuring cloth you would measure with the elbow to the fingertips first, and then ...

Shlly Yes, sometimes it is good. You go to the shop which also gives you extra. In the business you say "Oh! he get me extra."

Jean It is like, when my father who is dead now, when he was a child they used to make bread in batches and just tear a piece off and throw it on the scale and it would be bought in pounds and they would go to shops where they were given a little bit extra for the money.

D They tore off a piece of cooked bread.

Jean Yes.

D And weighted it.

Jean Yes, turn of the century, 1910.

D ... chosen questions. You can have a look through these or you can think about what maths you did in the last twenty four hours, if you like.

D Who wants to go next.

Shda Quite simply. In a way I am sometimes bad with time, but it says, "When were you coming out how did you decide what time you had to leave home?"

Clai I should have done that one.

D You can do it as well.

Shda But anyway I choose it because I am bad with time and timing and last night when I say "Okay I have to leave here, might have to get up at 8.00" because my son who is a year old gets up at 8.00 so I say "Okay I will get up at 8.00 and I will allocate an hour for his feed, okay". He takes sometime a long time, tiring to feed him, so then I say "I will finish feeding him at 9 o'clock and I will get ready for, maybe an hour will be 10 o'clock to get ready" but didn't think, didn't happen the way I plan it. First of all he, I had broken sleep because he was a bit unsettled last night so I woke up a couple of times and then I couldn't get up at 8.00. I woke up at half past eight and then I don't have watch, I lost my watch a few weeks ago and I wanted to be leaving house, to look at the clock on the wall, so it's half past eight and I say "Oh!, I'm still a bit tired, let me go back to bed, for another half an hour and Hassan was here". He got up and started crying in his bed. I took him out of his cot and put him beside me in the big bed so I could

Rhia Swing extra time.

Shda Yes, to get extra time. Then finally I get out of bed at 9 o'clock and then I start ... and his milk and his breakfast and I think I finish it at half past nine and for another half an hour I play with him. I have my breakfast and at 10 o'clock I wanted to wake my husband to leave the baby with him. But he was still in bed and he wanted to continue and say, "Oh! I'm tired and you are you leaving now" and I took Hassan up to him, walked into his room, he was there he slept in separate room and said "Get up, time to wake up, it is time I should leave". So he managed to get up at half past ten and was quarter to eleven and I wanted to leave but Hassan again cried when he see me leaving and wanted to be picked up and he wanted me to walk with him, so it took another ten minutes, I think, seven minutes, ten minutes and then I left home at seven to eleven and walked to Archway and then said I'll catch a bus, and "Oh I am going to be late", but ... I wait for five minutes and then I say "Oh! I won't wait any longer and walked.

D From Archway.

Shda From home to here, yeh. That is why I was late.

D A very good excuse. Anybody else have any nice stories about

Clai Well, I think because I am sometimes late for things, and I find there are things which I don't allow for is that I have got a rough idea in my head about, you know, how I have got to leave the house at this time, but what I never allow for is something will go wrong like a phone call or something happens. I think what really gets me sometimes is sort of when I am getting ready to go out, I never allow for the fact that I might not be able to find my shoes, that kind of thing.

Jean It is interesting ...

Clai I plan as if I am a well organised person and in fact I am not that well organised in knowing where my things are, so that is what I think, it is something to do with not allowing for things going wrong.

Shda Same for me. That's the problem sometimes. My husband has problem because I wait until the last minute and I don't give extra time for in case something goes wrong and the last minute I start to panic, you know. And he say "Look what you have done" but he always, he will give ... where it takes about half an hour he will take an hour and another half an hour extra and I say "You are not effective with time". You have to, you are trying to do something which is only a half an hour in one hour. Really that's what makes me a bad organiser.

D Is anybody different from these two.

Eil I am. I allow too much time so I am always early for things. I get to lectures half an hour early ... to go wrong and if it doesn't then I end up standing somewhere for ages waiting for people or something. I'm just over-organised, if it takes half an hour I allow three quarters of an hour. I need to get up at eight so I get up at half past seven just in case and end up just flapping around, so much time on my hands which I could be using better if I organise myself and realise that I spend too much time.

D I mean, do you prefer to be early.

Eil I prefer to be a bit early but sometimes for me it is half an hour to spare

D And are you the same.

Cath I have problems as well. Living in Harrow, there are two trains going into central London. There is the fast train and the slow train. And I never know which one it is going to be. So I have to allow for the fact that if it is going to be the slow train which takes an extra fifteen minutes or so and quite often I might catch the fast one and end up. I should look at the timetable and work out when it is, but that's too organised.

D So you know when the trains are due, but you don't know if there are the fast ones or not.

Cath Yeh. But I vaguely know that there is one every ten minutes or so, so you can't get more organised than that at the moment. So I allow usually about an hour to get the train to the centre of London and quite often I am there half an hour early. But if I didn't plan that, I could be late, because there are two different trains.

D So you would prefer to be early rather than being late.

Jean Is it something to do with how we, what sort of philosophy we have on life, you know, how we organise our lives. I am exactly the opposite to you. I tend to sort of go with the flow and, you know, sometimes I am very early and sometimes I am horribly late but there is not a lot, there is not a lot I intend to do about it, I suppose, that is what I am saying. It's something that, you know, I accept that is what I am and that is what I do.

D Right, so how do you organise, say, today when you were planning to come out.

Jean Well, I suppose I tend to pack in too much on, I try to do a lot more than I should, if I've got a sort of appointment, like this morning. I wanted to bake some, do some baking. I actually got up quite early and started my cooking quite early. I was up about half seven, quarter to eight and started the cooking process. But, it was a complicated recipe and I had to wait until the product was finished before I could come out. I suppose that was my downfall really.

D Right, so, did you work out how long it would take to do it.

Jean Well, no, no. I got up and started it, I think, I calculated, you know, the time of each part of the process, but I suppose it's because I don't do any exact quantifying of things, everything's approximate, I suppose that is what I am talking about, my philosophy. Everything is approximate. I just tend to go with the flow, if you know what I mean. When things are cooked, they're cooked, and I have to hang around until they're cooked, you know, I can't leave half-cooked. I suppose that is what I am saying, it's about a philosophy rather than a

D More of a feeling of time than a real ????

Jean Yes! that's right. Except ... as to how I do, like cooking, I don't set a time for baking, for example, a cake. I just see when it's cooked. I keep checking and I know when it's ready, it's cooked. I never set a time. I know when it's ready. I never set a time for baking.

Rhia I do the same thing with quantities. I know certain recipes but I never, very, very rarely unless I am doing something for the first time do I weigh anything out. I am making a Banofee Pie for example, which you have to get the toffee exactly right, otherwise it won't set or it will set too hard, but I always do it just by the kind of feel for the quantities rather than

Shda When I was living in ??? we had a cooker with clock. I never made use of it. It was just ??

Shlly I have a very sophisticated cooker but I don't know how to make it work. ...

D It has a clock on it but you don't use it.

Shlly Never, ever.

Clai I was always taught to know when a boiled egg is perfectly done by taking it out of the saucepan on a spoon and you look at it and you go, 'One elephant, two elephant, three elephant' and if by three elephants all the wet has steamed off the egg, it's perfect.

Mera Elephant, if you say elephant in between each count it's a second isn't it.

Cath But is that common myth or something like than. I use it by I am sure I have never been told about the elephant thing.

Jean I never heard of it before.

Cath I must try that.

D When you are thinking about time, how do you actually think about it when you are thinking, you know, would it take me an hour, would it take me half an hour. Do you see a clock in your mind or a digital clock or do you think of it in some other way.

Eil I see it as a diary page split into half hours and things and think, 'I have to be there then so I have that space before that, and that space before that, and that space before that.' I always overestimate it but that's how I think of ...

D Like a list of times

Eil Like a list of things, between ten and one I would be doing that, between one and two I would do that, between three I would do that. That's how I see it.

D Do you have a diary that actually looks like that.

Eil I used to, I don't now because I just do it in my mind now and I don't actually write things down.

D Sorry ...

Elea It's on the right side.

Eil I used to have a diary that was laid out like that, but now I don't write it down at all. I write down important things in my Filofax, but I don't write down ordinary things because I can do it in my head.

D But that is what is looks like.

Eil That's what I visualise as a diary like that.

D Anybody else do anything like that.

Elea I don't actually imagine a clock or a diary page, but I am adding it up. So if I get up at half past seven and I know it takes me an hour to get ready then I will add that up so that will be eight thirty. Then I'll know that it takes me forty minutes to get to work, so I'll try to add 40 minutes onto half past eight, like that. So it's not a clock and it's not a list, but it's just adding another hour, another forty minutes onto the time.

Rhia When you are adding your forty minutes, if I was adding half past eight plus 40 minutes, then I would definitely use like a half circle to do it.

D So you would be thinking of the clock face, you would be thinking of half an hour and another ten minutes.

Rhia The more complicated the calculations, the more likely I am to use a circle to like calculate.

D So it is not really a clock, it's just a circle.

Rhia Yeh. It's not really just abstract numbers, it's the, the actual, you know, half of the whole, half an hour.

D And what about the other ten minutes.

Rhia Which other ten minutes.

D If you are adding forty minutes on to half past eight.

Rhia Oh right! Well I'd do half past eight plus thirty plus ten so I'd get to ten past nine.

D Right, she is showing with her hand she is moving it from the half past position up to the hour position and moving it around to the ten past position.

Rhia In my exam, for example, working out how much time I can allocate to each question in a three-hour paper, where everyone has to answer four questions and you know, you've got the added onus of having to work that out.

D How did you work it out, Rhiannon?

Rhia Yeh. I just drew a circle at the top of the page and I still don't know the answer.

Ele Was that to represent the whole 3 hours.

Rhia It was to represent a clock face and, I mean it was a bad way of doing it, because I still don't know exactly how much time I allocated to each question. I think I just gave up and just started answering the questions because it was taking me too long to work it out.

D How did you try and work it out. You drew the clock face.

Rhia Yeh. I kind of imagined that forty minutes for each question first of all and then I traced from the top, from the 12 o'clock point to forty minutes and made a mark for one.

D Indicating .... round the clock

Rhia	And then, let's see, another forty minutes would be twenty past. So I made another mark and then another forty minutes would be up to the hour. So, that's two hours, is that two hours? Two hours for three questions.
D	So you had another hour for the last question
Rhia	So it was wrong, 40 minutes. About fifty minutes. Yeh. It was this kind of, not very exact, testing out of how much time, as I say I abandoned
D	That's why when you got to two hours and three questions, you gave up.
Rhia	I think it was at that point yes, I just decided that it's not a maths test.
D	Anybody else image clock faces.
Ruth	I think I might see the clock, because I always just go backwards from when I have got to, like I have got to be here at eleven, so that means I have to leave about ten. I think I just, sort of, more or less, see my clock, knowing that I've got to do this at that time. I never try and fit a lot of things in, I never get up and start baking bread or anything, ... squash it into the day really. But then I'm the same as Eileen. I will just allow loads of time, in case of a traffic jam. You know, I get to the airport a day before I'm meant to be flying. It's exciting. It's part of the holiday.
Mera	Yeh. I will miss my plane.
Clai	Getting the cab driver to ring the desk to say I am on my way, hold the plane.
Shda	Really.
D	Sounds like you actually did that, did you.
Clai	Yeh. I did actually.
D	Come on, tell us the story.
Clai	Well it was just, I was going to the airport and again it was this thing about not making enough time. So that I calculated two hours, that I would catch the taxi to go to Heathrow from Brixton 2 hours before the flight took off. So what I was thinking, that if I get there in about an hour and then it would be time to check in and get on the plane. But what I forget to take into account, was sort of mid-morning traffic in London. So after about an hour we were still sitting somewhere around Earls Court in a traffic jam. And so we rang, I got the cabdriver to ring the airport, luckily he had a mobile, saying, you know, to say that we are on our way. So what they actually did was, they didn't close the desk, they just left it open and then took the luggage straight on to the plane, because it was going to Paris first and then going on somewhere else. They put the luggage in the hold afterwards. So it was just really lucky that I got it.
Ruth	Causes stress, though, doesn't it?
Clai	It does, it does, I mean I just arrived at the airport, adrenaline pumping. You see I hate arriving anywhere early.
Ruth	It's a choice to be made, basically, isn't it.
Clai	I go for being on time. I mean I do try. I have a go for being on time.
Jean	I suppose
Clai	I don't like being early. I don't like being early. I think it's because I don't like people coming early to me because I am usually a bit behind. So I like, if you turned up early I'd be "Hello" (in a funny voice) "What are you doing here?"
Eil	I don't turn up. I go round the shops or something like that.
Clai	Oh you are one of those sensitive kind of people ...
Eil	I think for half an hour, "What am I going to do?" and then I turn up late because I've gone wandering and got lost.
Shda	Sometimes I find that pressure is what makes sometimes me to do something.
Ele	Yeh.
Shda	And I can finish, I can do a lot of things, if I am under pressure. In half an hour I can do many things, which I wouldn't do if I knew that I would have time. I would wait, sometimes for 2 or 3 days, I would do it in the last half an hour of the last day, what I didn't do when I had a whole week or 3 days.
Clai	Time is precious.
D	Does anybody else know how they sort of think about time.
Clai	I feel it, I don't visualise, but I feel I know when an hour is over. I do some teaching so I am used to doing 2 hours and at the

end of the first hour (snaps her fingers) there's a break, usually 10 minutes, and that's how I used to do it. So I can always tell, I can usually sense when an hour is over. But recently, in the last couple of years, I've started wearing a watch. And that, I used to be quite accurate and now that's going, now I've started wearing a watch ... But I certainly used to be able to sense sort of time blocks, much more effectively.

D When you say you can feel it, can you describe that more.

Ruth Kind of a bit spooky really, isn't it.

Clai I don't know, I just know (snaps her fingers) that this (snaps her fingers) is the time (snaps her fingers) to do it. Like sometimes I can wake up (snaps her fingers) at the right time.

Rhi If you know the night before that you have to be up at 7.30 and you don't have a clock sometimes you wake up.

Clai Yeh, usually 6.30.

Shda I think I am like that. I don't know. I feel it. I ... 2 days ago, because I lost my watch 2 weeks ago, I took my son to the community centre playgroup and I left at 3 o' clock and I came to Archway to buy things from the shop and then I had an appointment with someone at hospital, ..., and I didn't want to get delayed, to be late, so I asked the security man what time is it and he says, "Oh, I'm not sure if it was half past three." And I say, "I don't think, I think it is around a quarter to four", and then the woman at the counter looked at her watch, and it was exactly the time I said. So if I check, maybe in every 2 hours, if I check when the time was at 11 o'clock, then I can feel maybe about 2 or 3 hours ... what time is it in that period. I don't know, it's just, you know.

Rhi I suppose in harmony with your environment because of the amount of light and the quality of light and that must have come before these calculations, when they started making calculations about the day, splitting it into ever more minute parts. I suppose we used to go by the light.

Shda Exactly, like in Somalia that's the way we check time.

Shlly Still because it's my childhood habit, as I explained in my interview, I still count that, like in the evening, evening prayers, when I have guests at home, they sometimes ask me, "What time is the prayer?" Because they want to pray and I never be able to tell them unless I see the timetable. And they ask me, "How do you pray then?" I said, "I just look outside. If is getting dark, I can feel the time. It's not dark yet, it's not, you know, completely, it is going to be dark soon. So this is the time to pray." I can, I never look at the watch, I rather look at, you know, outside.

D So, in this country, when the

Shlly In the winter, it's different.

D The time varies, doesn't it when it gets dark.

Shlly That's right.

D Do you always pray at twilight or it is always at five o'clock?

Shlly It's at dusk, no not always, I mean evening prayer, it always depends on the sun, not the time. So people have, you know. Still I have got that in my mind. I don't always look at the watch I just look at the day.

D And are all the prayers connected to the sun.

Shlly Connected to the sun, yes.

D So here in the winter when the day is very short you have to?

Shlly Yeh. Here, quarter past three or three, something like that, it depends on the day.

D Right.

Shlly And you have a feeling of the day, how long the day will be in the winter, how long the day will be today. So it is still my childhood, maybe it's my childhood habit. I still, you know, I am still continuing.

D And do you have to get up at sunrise.

Shlly Honesty speaking I never did. But some people are very punctual. But prayer time are for people to be punctual: they should wake up in a certain time, have lunch at certain time or do certain things at certain times and those 5 time prayers to make them punctual. But I am never punctual, so.

D But are you supposed to get up at sunrise

Shlly Supposed to, yes. Supposed to get up at sunrise, yes.

D But it must be very hard, in the summer here, because the sun rises so early.

Shlly It's 4 o'clock or something like that, yes.

Shda The morning prayers.

Shlly But people do, you know.

D Do they? Then do they go back to bed.

Shlly Yes, if they don't have anything to do, yes, go back to bed, like my mother, my parents, they wake up with the sun, pray and then go to bed again. And if they have something to do, you know, people just continue.

D So it's 5 times a day you pray. One at sunrise

Shlly One at sunrise, one at sunset, in the evening , one at lunch time, one in between lunch and sunset and one at night before you go to bed. But you have more flexibility there for the evening prayer, yeh. But ideally you should keep the time. That's the one condition you know, the first condition of prayer, that you should keep the time. It's very strict and people follow, the people who practise prayer properly.

Shda They think it's lapsed, your prayer lapsed if you don't do it on time.

Shlly Yes, lapsed if we don't do it on time.

D So would you tell all those different times by the sun.

Shlly People, yes because I have seen in my village, you know people hardly have any, nowadays almost everyone but you know, 30 or 40 years ago, they didn't have any watch, maybe one clock, we had the first clock in our locality, an alarm clock, Big Ben or something like that. Nobody had any clocks so they just used to watch the sun and they ... their time and they were accurate. When the sun, when your shadow is, I mean you can work out from your shadow the time you can work out from your own shadow if you, ...

Shda I remember when I was young my father telling me to stand outside, to say his prayer he will know when it's the noon

D What happens to the shadow at noon.

Shda It's around you, it's not tall

Shlly Twelve o' clock it's compressed like that. (Clapping her hands together.) But after twelve your shadow will be longer and longer and longer until

D But now you are living here do you do it by the clock.

Shlly Still I have the feeling of the sun you know. But actually both I use now, to be accurate. In this weather, in this climate in England , you can't be accurate to the sun.

Ruth Would you know say, between 11 and 1, if you're shadow is presumably the same sort of length.

Shlly I am not that ... but you know, well we have a feeling that it's not noon yet.

Rhia Your belly tells you sometimes.

Ruth So you don't need to know the directions.

Shlly No, some people are very expert. I didn't give enough concentration on these. I didn't learn, but some people are very expert on that. And at my interview I told you for the prayer in the afternoon, lunch-time, midday afternoon and sunset afternoon there is another one in between. And there is a type of, we eat the vegetable. You can buy from here, from Brick Lane, that vegetable, it's long one. I don't know whether you do it in Somalia or not, the vegetables and the flower comes exactly at the same time every day. Same time, at about 5'ish in summer. So people, you know, village women, I used to see village women, "Oh, the flower has come. Go and pray." That flower indicates the time of that, you know, certain time of the day. And that is very accurate, it is my own experience. It comes exactly at the same time every day, blossom, I mean. And after that it goes back again, as the sun goes down the flower goes back again.

D She is showing with her hand how the flower closes up.

D Sheda, do you have a similar experience.

Shda Not with the flower, but looking at, you know, the prayer time. As I mentioned, my father used to ask me to go outside and check if it's the right time to pray. So we always, we don't have watch, these days people use in towns, but it is always the sun which tells you the time, when it is afternoon and evening, morning.

Rhia A friend of mine, who devoutly avoids wearing a watch because he says that the more conscious you are of passing time the more you are ravaged by time. Wasn't it Einstein who was really concerned with this problem of objective time, that's the same for everybody. But there's a subjective passing of time he was really worried about ... I think it is true, definitely.

Clai What do you mean subjectively. That time has different meaning for everybody?

Rhia Yeh. Time is the same for all of us, it's 12'clock in this room. But, for example, depending on how you are feeling, like I might, for me, this meeting might seem to pass really quickly, but for other people it might seem very slow

D I only have time to do one more question because we are going to run out of tape. ... Anybody like to talk about their questions. Meera, what did you get?

Mera "Can you remember, when you were planning to make something .... How did you work out what materials you needed?" That's quite a good question because I did pottery.

D Oh, right.

Mera ... like a big slab of clay and then you have to like take off bits of clay according to, you know, what you want you to make and which technique you are using and stuff. How I usually work it out is to have like some vision of what you want to make first, like what shape it's going to be, the size of it and how you want to make it. Because there's quite a few ways of making pots. I always make rough estimations of ... I'm not really precise about it but I just ...

D Can you tell us about a particular pot you made.

Mera Um, I wanted to make a quite small pot and use like coiling. What I did was I took off a certain amount of clay, about that much. I don't, I usually take small bits off at a time. I don't, you know, want to waste it, or anything. I am not very accurate, I'm not very precise at all, not very good at making guesses ... So, take a bit of clay at a time

D She is showing us with her hands ...

Mera ... make coils, roll them out on the base of it and then you kind of use a template for the base and then put all the coils on top and kind of wind them round and build them on top of each other.

D Did you make the template yourself, or.

Mera Yeh. It's how much you want the base to be.

D So what, do you cut it out of cardboard or something.

Mera I usually use like another object, to sort of draw around and cut around it.

D Oh, that's on a piece of paper.

Mera No, on the actual clay. You roll it out first and then you ...

D Oh right, you put one object on top, you've rolled the clay out flat, and you put the object on top and cut around it.

Mera Yeh. That's the base and then you have to make your indentations around the bottom and then you put slip around it and then you have to build on top of it, like build it according to which shape you want, like whether you want it to come out or whether it want it to be straight or want it to sort of come out and then go in.

D She is showing the shape with her hand going outwards and coming in.

Mera It's another intuitive thing, I don't really think, when I do it, I don't think mathematically or anything.

D So when you say you have a vision of what you are going to make, do you see it very clearly in your mind.

Mera Yes.

D And you know exactly what size it is.

Mera Oh, yeh. Roughly. Yeh. *(Very hesitantly.)*

D And when you are making these coils, can you, you don't have to roll out a great long sausage to make the whole pot. You can join them together, can you, so you can take another bit of clay and.

Mera You can make thick ones or thin ones, small ones.

D So this pot you were making, was it thick or thin.

Mera It was quite thick, yeh. I tend to make thick ones.

D And can you join the coils together.

Mera No, not really. What do you mean? Like have one coil and put another one and join it up and then use it?

D Yes.

Mera No, not really. You can't.

D So that does mean you have to roll out the whole coil to make the whole pot.

Mera Oh no, you can like, you make small ones and build them on top of each other. But then you can't really do that with one coil.

D So your pot looks like this.

Mera Sort of went up and went on ... really close you know, they kind of measure the clay and roll it out and use sticks and you know to keep it all in line and I am just totally not like that, you know, do it how I feel, you know, just working a rough estimation, but nothing accurate.

D So does the pot turn out the shape and size you expected it to.

Mera I didn't have a really fixed vision of what I wanted it to be, but roughly, more or less.

D Anybody else do pottery?

Mera It says sewing and woodwork as well

Ele I am doing my cross-stitch. I am doing a picture that has got a tree and it's all symmetrical and underneath the tree there's two foxes sitting underneath and their faces, I know exactly, they are meant to be exactly the same. I did one fox and then I did another one and I had a chart and its got all symbols on for you know the different colours and

Ele Is that the end of that one, shall I call on.

D Yeh.

Ele So when I finished the foxes they looked different, and I had to kind of count each, or look at each line separately to see which ones I've made different lengths. And one fox is much thinner than the other one and I had to kind of add some stitches. But now the outline is not the same, it's just, it doesn't really matter but it kind of frustrates me because I think "Why can't I follow this chart." But I am going to buy something that you put the chart on top of a metal plate and a magnetic ruler across it, so you can move it down line by line. So you can read the line you are working on. You can focus on it much more clearly and hopefully that will be easier. It's really difficult for me to count, like 5, starting from 1 less than the previous line and ...

D That wasn't a pattern that you had drawn yourself, it was one, published one.

Elea Yeh.

Jean I think with a lot of things, you know, things that seemingly are very sort of spiritual or sort of ... things, you do need a lot of maths. Say for example dancing, tap dancing is all maths, all sort of rhythm and counting. And I, many years ago, I decided I wanted to learn tap dancing and I went to this class. I couldn't do it because I can't count, I just could not count. It's a question of concentration and if you lose your concentration to count, you've lost the whole sense of it. And I do admire people who can, you know, this is ostensibly a very spiritual thing but it is about counting as well.

Rhia Concentration!

Ele It probably doesn't help that I try and watch the telly at the same time. It's not as spiritual as it might be.

Rhia I had the same thing, trying to learn to do some African dancing. And a lot of it was clapping and there was like, you had to clap twice and then two to the front and stamp twice and I would have to clap under here. And always I should have gone on with the music which might have made it easier, but there was no music so it was just rhythm and counting and it was really, really difficult, you know. I was puffing and panting at the end. Very hard to concentrate, because you think of dancing as being a very intuitive thing, but it was so rigorous and exact. And I think the teacher, because he was like a natural musician, he had the sound of the music in his head, so he had the natural rhythm to do. It but everybody else, because there was no music, was just relying on counting and you know the spaces in between. Such hard work, it really was.

Shda That's was I was going to say. This person is maybe subconscious, it's not thinking about counting you know, clapping or

Rhia No, he wasn't.

Shda Just there was something wrong with it, just intuition. Something tells it is not the right rhythm but they are not thinking of how many times I am going, we have that kind of dance in Somalia. Nobody thinks of counting or conscious of what they are doing, just they know when everything is right and.

Rhia It's the same with drumming, because I tried to learn from the same teacher to play the African drums. And I found that I could keep the rhythm, but once I started to try and put, impose like a number on the rhythm, like this is a four-time rhythm, or go 1,2,3,4,5,6, 1,2,3,4,5,6. I found that that really put me off and I just couldn't do it at all. Yeh. It's an intuitive thing.

D How do people learn the dance or drumming in Somalia. Do they learn it when they are very small children.

Shda I think, people don't go to school to learn their music, there is no certain age, I think.

D They just learn it from seeing.

Shda From seeing other people doing, yes. Many people I know, they start when they were quite old, by chance.

D Yeh, so how did they begin then.

Shda When they see other people doing, just being in the group and watching others. For example, now in London I go to Somali weddings and some women can dance and others just watch. And I had some people would like, I myself the kind of person I would like to do when I go there, but I can't dance. And some of my friends they say they learn at home, and they say "Oh I hope next time when I go to a wedding I want to dance also." So.

D So they practise at home.

Shda They practise at home and they try and some of them even they tried, at the wedding, you could see some of them they completely

D Yes

END OF SESSION

Appendix 3. Everyday Maths Group coding list

- identification of goals
    - affectivity (preference)
    - description of goals
- planning the process of achieving the goal
    - conceptualisation of the result
        - visualisation
        - tools
    - obtaining information
        - remembering previous experience/knowledge
            - cultural patterns
            - intuitive/subconscious
        - from elsewhere
        - measurement
            - standard units
                - tools
            - traditional or natural units
                - tools
        - estimation without tools
        - calculation
            - methods
        - making comparisons
        - representation
    - affectivity
- execution of task
    - process
    - learning
        - process of learning
            - by observation of other people
            - from instruction
            - practice
    - resources/tools
    - affectivity
- reviewing the execution of the task / achievement of goal
    - affective issues
        - perception of ability
        - habits
        - relationships
            - others' reactions

Appendix 4. Example of coded fieldnotes of visits to gardeners

Yew Tree Road -13/6/97

Arrived at 10.30am. Joe, Ben and Gerry. Garden at back of terraced house. Access through house which was covered in dust sheets. Small conservatory built onto large kitchen. Opening onto patio which extended width of the house, but on two levels divided by a brick wall. Two steps up to lawn.

Joe said Mick the brickie had messed things up a lot. He'd laid the patio before building the walls all round it. The patio is made of square stone slabs laid on cement, laid on special ballast which is packed down with a machine and is very stable - used in road building. Walls should have footings but Mick had built them on top of the patio stones.

Step to French windows had been made at level of the lintel 'to hide the damp course' which was too high. Had to be lower and wall made good. Joe now satisfied with result, but had taken too long and put them behind. Drainage hole had been put near the lowest corner but the corner was likely to collect water. Mick had also put drainage. Joe had offered to draw plans, but Mick said he didn't need them. Disputed whether he'd been asked for walls at end of lawn. Joe said it was obvious hole from flower bed to patio - stupid idea. Gerry suggested putting hole in wall between two levels of patio. Also drainage hole in lower patio. Joe said, "could do".

Mick had not finished properly round drain hole for down pipe of house - house would get wet. Mick subcontracts from Joe. Had quoted £950 for work, but it cost £1600. Joe had to absorb this in £5000 for whole garden - fixed price. He had also had to make many trips for materials for Mick - doesn't have a van - had underestimated 90 slabs but needed 120 - always some wastage. Mick always insists on full payment if he over-estimates. Joe pointed this out to him, but didn't want to waste time arguing.

Ben and Gerry tying up rose bush onto deck - working slowly. Then Ben cutting some wood off trim to deck. Gerry digging up soil next to deck found lots of pieces of concrete - old wall. Dug up - wheelbarrow full. Also bindweed roots. Bindweed had been all over the rosebush - picked off.

Ben sent to Ally Pally garden centre to buy weed suppressing sheet to put under deck - Joe phoned first. When he came back had paid £14.50 with 10% discount instead of £9.50, which Joe had been quoted on the phone. Garden centre told Ben he'd quoted the price for another kind. This kind you could plant on top of. Also 8m x 1.5m instead of 8m x 3m. Joe annoyed in a mild way.

Ben and Gerry measured out the sheet and cut two pieces 4 ft long - they knew this measurement from building the deck. Gerry crawled under with one sheet. Ben passed him pieces of concrete from the wheelbarrow to anchor it and scissors to cut it round posts. Then other sheet.

I asked Joe who chooses the plants. He said he'd given owners four books to look at and make a list but they hadn't. Preferred to choose - could spend a lot of time going round garden centres looking for particular plants. Customers complain if too much space between plants but need space to grow. Can buy large plants but a rhodedendron 4 feet across, (showed with hands), could cost £80.

He showed me a big pile of mulch made from composted bark with sand mixed in. Could be used for any plants - slightly acid. Most soil is slightly acid. How to add lime if planting ericaceous plants (or do they like acid??) Doesn't usually test soil but has probe can put in soil which gives instant reading - chemical reaction with probe. Puts mulch in planting holes.

I asked about Freddie - no longer working for Joe - job at Larch Place was the last one. Talked too much and did too little. Didn't know much about gardening. Had told Joe he did - had had an allotment for a year. Had planted 80 herbs close together in a space for about 20. Joe had to thin out.

Joe saw Ben and Gerry working quite well together. Had had to give them several pep talks and threaten them. Gerry said he was going to buy chocolate - flaked out from digging. Went off for 10 minutes.

Deck on stilts in part of garden, sunny in evening, picnic table. Said they'd built it too high. Could be seen from neighbouring gardens. Owner wanted climbers over it for privacy. After putting weed suppressing sheets under it, Ben and Gerry were cutting fencing boards to cover to space - owner didn't want to use space for storage - Joe thought waste of space. Shed was going to be put at end of garden on right. Ben and Gerry discussed with Joe whether boards should just cover posts or extend to fence. Joe said just cover boards. Ben and Gerry measured them up against posts and drew a line on board for sawing. Joe asked them whether they were going to saw the boards before or after they nailed them up. They said after because top of deck would get in the way.

Had built a fence all round the garden overlapping vertical planks. 'Good side' faced garden. Asked Joe wasn't right hand fence property of next door and he said technically, yes. Fence very expensive.

Joe said flower bed on right hand side was wide and on left hand side was narrow - wrong way round because left hand bed would get most sun - was going to swap them round. I asked him how he knew where the sun was - obviously thought it a silly question - said he'd had plenty of opportunity to observe it. They'd been working on the garden for two weeks. Gerry also pointed out where the sun went round.

The lawn was going to cover most of the middle of the garden - to be laid on Monday when the turfs to be delivered. Had to be covered quickly with plastic sheets when it started to rain - would become a quagmire and turf could not be laid. Joe again spent quite a long time moving things around. Also on telephone. He said he'd tried out a few women gardeners since Freddie left, but they'd left. Needed someone experienced. Had no time to teach.

Joe talked about estimating: said big firms say they take into account time workers spend in cafes and double whatever figure they come up with - takes into account delays - eg. waiting for turfs to be delivered - might arrive at 4pm and waste whole day.

On Monday they are going to lay the lawn and I think I'll go and see - maybe at the beginning and the end - if they mark out - and fitting in the last pieces. Arranged with Joe to go with him to do estimates this afternoon and tomorrow morning. Said there were books you could get and computer programmes - tell you how to do estimates in various trades, including gardening.

Appendix 5. Matrix of structures of problems and solutions

Part-icipants	Stories	One off	Routine	Conven-tions	Idiosyn-cratic	Simple	Complex			Closed	Open-ended	Formal tools	Avoid form tools	Informal tools	Formal methods	Avoid frmal mth	Informal methods	Estimatn	Calculatn	Spatial th
							Compnd problems	Multiple variables	Qualittive variables											
Upholstery																				
Alice:	pattern of canes	*		*			*			*				*			*			*
Beattie	making false buttons	*		*			*			*										*
Carol	stripping down chair		*	*			*				*									
Denise	repairing a chair frame	*		*			*			*										
Evelyn	re-cover a settee		*	*			*		*		*									*
Evelyn	repair a chair frame	*		*			*			*										
Felix	re-uphol mod arm-chair		*	*			*		*		*									*
Grace:	piping a cushion cover	*		*			*		*	*										*
Sean:	measuring fabric		*	*		*					*		*	*		*	*	*		*
Sean:	orienting fabric		*	*		*					*		*	*		*	*			*
Gardening																				
B & Gerry	preparing lawn bed		*	*			*										*	*		
B & Gerry	finishing patio		*	*			*										*	*		*
B & Gerry	finishing deck	*					*										*	*		*
B & Gerry	pruning wisteria	*		*			*										*			
Joe:	measuring with body:		*	*			*		*				*	*		*	*	*		*
Joe:	mixing spray for roses:		*	*			*		*		*					*	*	*		
Joe:	planning garden:	*					*	*	*								*	*	*	*
Joe	expanding the business	*					*	*	*									*	*	
Joe	fences neighbours	*		*		*			*									*	*	*
Joe	calculating area		*				*					*			*			*	*	*

Part-icipants	Stories	One off	Routine	Conven-tions	Idiosyn-cratic	Simple	Complex: Compnd problems	Complex: Multiple variables	Complex: Qualittive variables	Closed	Open-ended	Formal tools	Avoid form tools	Informal tools	Formal methods	Avoid frmal mth	Informal methods	Estimatn	Calculatn	Spatial th
Gardening																				
Joe	organising the work		*				*		*								*	*	*	
Joe	caps for fence posts		*			*													*	
Joe & Mick	contract	*		*			*		*									*	*	*
Joe & custome	choosing plants		*				*	*	*									*	*	*
Joe & Ben	weed suppressing sheet	*				*						*			*			*	*	*
Joe & Freddie	too many plants	*				*											*	*		*
Joe & Lee	lawn angles	*				*			*				*	*		*	*	*		*
Lee:	laying the lawn		*	*			*		*				*	*		*	*	*		*
Everyday Maths Group																				
Cathy:	catching trains:		*		*		*		*		*		*			*	*	*		
Cathy:	choosing books for library		*	*				*	*		*	*					*	*	*	
Cathy:	manag library budget		*	*			*			*		*			*				*	
Cathy:	managing her own money		*		*		*			*		*			*				*	
Claire:	boiled eggs		*	*	*	*					*		*	*		*	*	*		
Claire:	cntng lngths swim		*		*	*				*		*					*	*		
Claire:	going to the airport:	*			*		*		*	*		*					*	*		
Claire:	extra money in account	*				*			*	*		*					*		*	
Cl & Sheda	know time wtht clcks		*			*				*			*	*		*	*	*		
Eileen:	diary page		*		*	*				*			*	*				*		
Eileen:	on train: 24 hour clock		*	*		*				*		*			*				*	
Eileen:	trains: rounding up		*	*		*				*			*			*	*		*	
Eileen:	trains: visualising calc		*		*	*				*		*			*				*	

Part-icipants	Stories	One off	Routine	Conven-tions	Idiosyn-cratic	Simple	Complex: Compnd problems	Multiple variables	Qualitive variables	Closed	Open-ended	Formal tools	Avoid form tools	Informal tools	Formal methods	Avoid frmal mth	Informal methods	Estimatn	Calculatn	Spatial th
Everyday Maths Group																				
Eileen:	trains: forms stock cash		*	*			*			*		*			*				*	
Eileen:	trains: using pencil paper		*	*		*				*		*			*				*	
Eileen:	trains: combining prices		*	*		*				*							*		*	
Eileen:	trains: school algor		*	*		*				*		*			*				*	
Eileen:	trains: pool takings tips		*	*			*			*							*		*	
Eileen:	trains: coins tools count		*	*		*				*				*		*	*		*	
Eileen:	trains: cashing up		*	*			*			*		*			*				*	
Eileen:	trains: reconcil cash stock		*	*			*	*		*		*			*				*	
Eileen:	train: total prices		*	*		*				*		*			*				*	
Eileen:	train: mental calc		*			*				*							*		*	
Eileen:	train: multply 10, 20		*			*				*							*		*	
Eileen:	money for Fleadh	*			*		*		*		*						*	*	*	
Eil & Eleanor	cross-stitch	*		*			*		*	*		*		*	*		*		*	
Eleanor:	mortgage payments	*			*	*				*			*	*		*	*		*	
Eleanor:	adding time		*			*				*					*			*		
Eleanor:	cntng lngths swim		*	*		*				*		*					*	*		
Eleanor & Ve	counting OHTs		*	*		*					*			*	*			*	*	
Jean:	managing her own money		*		*		*	*	*		*		*			*	*	*		
Jean:	visual rep of money spent		*		*		*			*				*	*				*	
Jean:	clients' money: change		*		*		*			*							*		*	
Jean:	measuring furniture on l	*			*	*					*		*	*		*	*	*		
Jean:	cooking without calc		*		*		*				*	*	*			*	*	*		
Jean:	calc clients' benefits		*		*		*			*		*					*		*	
Jean:	orange and choc cake	*			*		*				*						*	*		

Part-icipants	Stories	One off	Routine	Conven-tions	Idiosyn-cratic	Simple	Complex: Compnd problems	Complex: Multiple variables	Complex: Qualittive variables	Closed	Open-ended	Formal tools	Avoid form tools	Informal tools	Formal methods	Avoid frmal mth	Informal methods	Estimatn	Calculatn	Spatial th
Everyday Maths Group																				
Jean:	tap dancing		*			*				*		*			*				*	
Jn, Rhi & Shd	dancing and drumming		*			*				*		*							*	
Meera:	making clay pots		*		*	*		*	*		*		*			*	*	*		
Rhiannon:	exam	*			*	*				*			*	*		*	*		*	
Rhiannon:	in the supermarket		*		*		*	*	*	*			*	*		*	*	*		
Rhiannon:	calc hours and wages	*			*		*		*		*			*		*	*		*	
Rhiannon:	finding her way	*			*		*		*	*			*	*		*	*			*
Rhiannon:	manage time, cleaning		*		*		*			*				*			*	*		
Ruth:	calculating 50%		*	*		*				*			*			*			*	
Ruth:	working the till		*	*			*	*		*		*			*			*	*	
Ruth:	using a pool of change		*	*			*			*				*	*				*	
Ruth:	spoilt child		*		*	*			*		*		*			*				
Ruth:	record video progs		*		*		*		*	*			*	*		*	*	*		
Ruth:	furniture: sheets of pape	*			*	*			*		*		*	*		*	*	*		*
Ruth:	using maps to come	*		*			*			*		*			*					*
Ruth:	learning to use a calcula	*		*			*					*			*				*	
Ruth:	spreadsheets		*				*			*		*			*				*	
Ruth:	visualising clock		*							*				*			*	*		
Ruth:	looking at TV paper		*				*		*		*	*							*	
Ruth:	using Greek money		*			*					*	*				*	*			
Sheda	getting up and going out	*			*		*		*		*	*			*			*		
Sheda:	wanting to make bookca	*					*		*		*	*			*				*	*
Shelley:	tape measure: bunk beds	*					*			*		*			*			*	*	*
Shell & Sheda	time for prayer		*	*		*				*			*	*		*	*	*		

Part-icipants	Stories	One off	Routine	Conven-tions	Idiosyn-cratic	Simple	Complex			Closed	Open-ended	Formal tools	Avoid form tools	Informal tools	Formal methods	Avoid frmal mth	Informal methods	Estimatn	Calculatn	Spatial th
							Compnd problems	Multiple variables	Qualittive variables											
Everyday Maths Group																				
Vera	assess health care plans	*					*	*		*		*			*				*	
Vera, Ruth, Je	diff with 24 hr clock		*	*		*				*			*						*	
Shell & Sheda	traditional measurement		*	*		*				*				*			*	*		*
Shd, Slly, Rhi	cooking without clocks		*			*					*		*					*		
Vera:	hours worked self-build		*				*			*		*			*				*	

Appendix 6. Matrix of emotion and Identity

Part-icipants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Upholstery												
Alice:	pattern of canes	*	slow								*	
Beattie	making false buttons		*					*		*		
Carol	stripping down chair	*									*	
Denise	repairing a chair frame		*					*		*		
Evelyn	re-cover a settee, repair a chair frame	*			*			*		*		*
Felix	re-uphol mod arm-cha	*								*		*
Grace:	piping a cushion cover		*			with Sean		*		*		
Students	app of Sean						*	*		*	*	*
Sean:	measuring fabric	*								*		
Sean:	orienting fabric	*								*		
Sean:	how he learnt	*					father, brothers sister			*		
Sean:	daughters						*			*		*
Sean:	how students learn							*		*		*
Sean	method of teaching	*							*	*		*

Part-icipants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Gardening												
B & Gerry	preparing lawn bed	*								*		
B & Gerry	finishing patio	method								*		
B & Gerry	finishing deck		how to cut side panels								*	
B & Gerry	pruning wisteria		2 plants?							*		
Freddie	different kinds of compost		*							*		
Joe:	measuring with body:	familiarity, tradition			*					*		*
Joe:	mixing spray for roses	until I questioned safety	*							*	*	
Joe:	planning garden:	*								*		*
Joe	confidence in prof exp	*								*		*
Joe	expanding the business		*							*		
Joe:	how workers learn											
Joe	fences neighbours	conventions								*		
Joe	calculating area	*	*							*		
Joe	doesn't like plastic trellis				*					*		*

Part-icipants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Joe	planting by the moon	part of a tradition								*		*
Joe	promote customers' confidence	*									*	*
Joe	organising the work	*										
Joe	types of soil	*								*		
Joe	caps for fence posts	*								*		
Joe	lawn path	*			dislike					*		*
Joe & Mick	contract		*			*				*		
Joe & custome	choosing plants	saves time			*					*		
Joe & Ben	weed suppressing sheet					*					*	
Joe & Freddie	too many plants					*				*		*
Joe & Lee	lawn angles	*			like and dislike					*		*
Lee	confidence in prof exp	*									*	*
Lee:	laying the lawn	*								*		*
Everyday Maths Group												
non-attenders				*						*	*	
Cathy:	catching trains:	*			avoid timetables					*		
Cathy:	choosing books for lib	*								*		*
Cathy:	manag library budget	*								*		*
Cathy:	confidence in prof exp	*								*		*

Participants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Cathy:	managing her own mo	*		?	being meticulus					*		*
Claire:	boiled eggs	*								*		
Claire:	counting lengths of the swimming pool	*								*		
Claire:	feelings about time			?	dislikes being early					*		*
Claire:	going to the airport:			adren-aline pumping						*		
Claire:	extra money in account		*	*						*		*
Cl & Sheda	know time wtht clcks	*								*		*
Eileen:	diary page	*								*		
Eileen:	on train: 24 hour clock	*								*		
Eileen:	trains: rounding up	*								*		
Eileen:	trains: visualising calc	*								*		
Eileen:	trains: forms stock cas	*								*		
Eileen:	trains: using pencil pa	*								*		
Eileen:	trains: combining pric	*								*		
Eileen:	trains: school algor	*								*		
Eileen:	trains: pool takings tip	*								*		
Eileen:	trains: coins tools cou	*								*		

Part-icipants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Eileen:	trains: cashing up	*								*		
Eileen:	trains: tips discrepanci	*								*		
Eileen:	trains: reconcil cash st	*								*		
Eileen:	train: total prices	*								*		
Eileen:	train: mental calc	*								*		
Eileen:	train: multply 10, 20	*								*		
Eileen:	feelings about time			?	dislikes being late					*		*
Eileen:	money for Fleadh				choosing purchases					*		
Eil & Eleanor	cross-stitch		*							*		
Eleanor:	mortgage payments		*							*		
Eleanor:	adding time	*								*		
Eleanor:	counting lengths of the swimming pool		*	*						*		*
Eleanor:	counting OHTs	*								*		*
Jean:	managing her own mo	*		*		*				*		*
Jean:	visual rep of money sp	*	*							*		*
Jean:	clients' money: change			*						*		
Jean:	feelings about time			*						*		*
Jean:	an addition person			*						*		*
Jean:	an honest person	*								*		*

Part-icipants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Jean:	measuring furniture or	*								*		
Jean:	cooking without calc	*								*		
Jean:	calc clients' benefits	*								*		
Jean:	orange and choc cake		*							*		
Jean:	tap dancing		*							*		*
Jn, Rhi & Shd:	dancing and drumming		*							*		
Meera:	making clay pots	*			Avoid weighing clay					*		
Rhiannon:	exam		*	?	Avoid calc					*		
Rhiannon:	in the supermarket		*	?	Avoid calc budget					*		
Rhiannon:	calc hours and wages	*								*		
Rhiannon:	learning from boyfriend									*		*
Rhiannon:	finding her way	*		*	*					*		*
Rhiannon:	timing work	*								*		
Rhiannon:	mnemonics	*								*		
Rhiannon:	spiritual person											*
Ruth:	calculating 50%		*		*					*		

Part-icipants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Ruth:	numbers		*	*						*		*
Ruth:	working the till		*	*						*		*
Ruth:	remembering PIN			?							*	
Ruth:	using a pool of change											
Ruth:	spoilt child			?	*						*	*
Ruth:	remember phone nos		*							*		
Ruth:	record video progs	*								*		
Ruth:	furniture: sheets of paper		*		*					*		
Ruth:	using maps to come	*								*		
Ruth:	maps	*								*		*
Ruth:	learning to use a calcu	*								*		*
Ruth:	spreadsheets	*				*				*		*
Ruth:	visualising clock	*								*		
Ruth:	friends penny count		*							*		*
Ruth:	looking at TV paper	*								*		
Ruth:	not crowd schedule				not to do too much						*	*
Ruth:	using Greek money	*								*		
Ruth:	learning logs										*	
Sheda	getting up and going out:						*			*		*
Sheda:	wanting to make bookcase		*							*		

Part-icipants	Stories	Emotions										Identities
		Amount of confidence		Anxiety/ fear/ embarr-assmnt	Choices & prefer-ences	Annoy-ance/ anger	Family pride/ Apprec-iation/ Love	Dep-end-ency	Contrl	Ex-plicit	Im-plicit	
		Confidence in expertise	Lack of confid-ence									
Shelley:	tape measure: bunk be	*								*		
Shell & Sheda	time for prayer	tradition								*		*
Shell & Sheda	traditional measureme	*								*		*
Shd, Slly, Rhi.	cooking without clock	*			*					*		*
Vera:	hours worked self-build		*								*	
Vera:	LETS schemes	*								*		
Vera:	theoretical knowledge	*								*		
Vera	assess health care plans		*							*		
Vera	counting slides	*	*							*		
Vera, Ruth, Je	diff with 24 hr clock		*							*		

Appendix 7. Matrix of categories of tools

Part-	Stories	Tools																
		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informal tools	Paper and pencil	Printed inform-ation				Sense of pattern	Count-ing	Calcul-ation	Visual-isation	Maths con-cepts	Memory	Intuit-ion
Upholstery																		
Alice:	pattern of canes		holes drilled in chair frame									sense of pattern						
Beattie	making false buttons	*				*												
Denise	repairing a chair frame	dowelling peg				*												
Evelyn	re-cover a settee		orientation of stripes									matching						
Evelyn	repair a chair frame					piece of wood												
Grace:	piping a cushion cover		fitting piping to material, esp round corners									fit						
Sean:	measuring fabric		measuring fabric against chair									fit						
Sean:	orienting fabric		orientation of stripes on chair									right angles						
		2	5	0	0	3	0	0	0	0	0	5	0	0	0	0	0	0

		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informal tools	Paper and pencil	Printed inform-ation				Sense of pattern	Count-ing	Calcul-ation	Visual-isation	Maths con-cepts	Memory	Intuit-ion
Gardening																		
B & Gerry	preparing lawn bed																	
B & Gerry	laying patio			set square, pencil, ruler								fit				right angles		
B & Gerry	constructing deck			tape measure														
B & Gerry	pruning wisteria																	
Joe:	measuring with body:				prefer-ence					*								
Joe:	measuring with tape			tape measure														
Joe:	mixing spray for roses:					spray contain-er		*									mem-ory of prev exp	
Joe:	planning garden:		garden	tape measure		mater-ials, plants			weather	body measur-mnt	custom-ers, workers				*		mem-ory of prev exp	
Joe	expanding the business				no written plan						workers	*		*			mem-ory of prev exp	
Joe	calculating area			tape measre, calcul-ator										mental calc		areas of tri-angle, quad		
Joe	planting by the moon								*									
		0	1	5	2	2	0	1	2	2	2	2	0	2	1	1	3	0

		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informal tools	Paper and pencil	Printed information				Sense of pattern	Counting	Calculation	Visualisation	Maths concepts	Memory	Intuition
Joe	organising work										workers			*	*			
Joe	caps fence posts												*					
Joe & Mick	contract				no drawn plans						builder	*		*	*			
Joe & custome	choosing plants		*						*						*			
Joe & Ben	weed suppress-ing sheet			tape measure				measr-ments on packet						*				
Joe & Freddie	too many plants		*									*			*			
Joe & Lee	lawn angles		*			sticks and string						*						*
Lee:	laying the lawn		*									*			*			
		0	4	1	1	1	0	1	1	0	2	4	1	3	5	0	0	1

		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informa l tools	Paper and pencil	Printed inform-ation				Sense of pattern	Count-ing	Calcul-ation	Visual-isation	Maths con-cepts	Memory	Intuit-ion
Everyday Maths Group																		
Cathy:	catching trains:				no time-table									mental calc				
Cathy:	choosing books for library			comput-er records				date labels, library slips, info on courss, student nos					*	*				*
Cathy:	manage library budget						*							*				
Cathy:	managing her own money						*							*				
Claire:	boiled eggs				no clock, egg-timer	water on egg							count-ing elephnt s					
Claire:	counting lengths of the swimming pool	*				clock-which end of pool								mental calc		odd or even nos		
Claire:	going to the airport:										taxi driver, airport staff			mental calc				
Claire:	extra money in account							printed balance						mental calc			*	
Cl & Sheda	know time wtht clcks				no clocks													*
Eileen:	diary page	*			no diary										diary page			
		2	0	1	4	2	2	5	0	0	2	0	2	7	1	1	1	2

		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
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			Object/ space being worked on	Formal tools	Avoid frml tools	Informal tools	Paper and pencil	Printed inform-ation				Sense of pattern	Count-ing	Calcul-ation	Visual-isation	Maths con-cepts	Memory	Intuit-ion
Eileen:	on train: 24 hour clock			forms										*		*		
Eileen:	trains: rounding up													*				
Eileen:	trains: visualising calc	*													visual-ising calc			
Eileen:	trains: forms stock cash		cans of coke, etc, cash	forms														
Eileen:	trains: using pencil paper						*							*				
Eileen:	trains: combining prices													mental calc			*	
Eileen:	trains: school algor						*							school algorithms				
Eileen:	trains: pool takings tips		cash										*	mental calc				
Eileen:	trains: coins tools count		cash										*	mental calc				
Eileen:	trains: cashing up		cash	forms									*	mental calc				
Eileen:	trains: tips discrepancies		cash										*	mental calc				
Eileen:	trains: reconcil cash stock		cash, stock										*	mental calc				
		1	6	3	0	0	2	0	0	0	0	0	5	10	1	1	1	0

		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informal tools	Paper and pencil	Printed inform-ation				Sense of pattern	Count-ing	Calcul-ation	Visual-isation	Maths con-cepts	Memory	Intuit-ion
Eileen:	train: total prices												*	mental calc		*	*	
Eileen:	train: mental calc													mental calc		*		
Eileen:	train: multply by 10, 20													mental calc	visual-ising calc	*		
Eileen:	money for Fleadh													mental calc				
Eil & Eleanor	cross-stitch			cross-stitch pattern, guide								*	*		*			
Eleanor:	mortgage payments													mental calc		*		
Eleanor:	adding time													mental calc				
Eleanor:	counting lengths of the swimming pool										*		*					
Eleanor:	counting OHTs	*											*	heur-istic				
Jean:	managing own money																*	*
Jean:	visual rep of money spent	*				large sheet with bills + calcs								*				
Jean:	clients' money: change													*				
		2	0	3	0	1	0	0	0	0	1	1	4	9	2	4	2	1

		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informal tools	Paper and pencil	Printed inform-ation				Sense of pattern	Count-ing	Calcul-ation	Visual-isation	Maths con-cepts	Memory	Intuit-ion
Jean:	measuring furntre on bdy				no tape-measure					*								
Jean:	cooking without calc		*		no clock or calcul-ation													*
Jean:	calc clients' benefits						paper + pencil							non-stand alg				
Jean:	orange and choc cake		*															
Jean:	tap dancing									*			*				*	
Jn, Rhi & Shda	dancing and drumming		*							*			*				*	
Meera:	making clay pots		*		no weighing													*
Rhiannon:	exam	*			no dividing	circle to rep clock	*								*			
Rhiannon:	in the supermarket													mdng prices, mntlly adding				
Rhiannon:	calc hours and wages						paper and pencil							non-stand alg				
Rhiannon:	finding her way			map	no A-Z	land-marks					other people, bus-driver				map in head			*
Rhiannon:	timing work	*			no clock or calcul-tion				radio progs								*	*
Rhiannon:	mnemonics																*	
		2	4	1	6	2	3	0	1	3	2	0	2	3	2	0	4	5

		Created tools	Environmental								Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informal tools	Paper and pencil	Printed information				Sense of pattern	Counting	Calculation	Visualisation	Maths concepts	Memory	Intuition
Ruth:	calculating 50%																*	
Ruth:	working the till			till		cash							*	mental calc				
Ruth:	remembering PIN																*	
Ruth:	using a pool of change	*	cash															
Ruth:	remember phone nos																*	
Ruth:	record video progs	*			no listing, calcul-tion	erasble labels												
Ruth:	furniture: sheets of paper	*				sheets of papaer									*			
Ruth:	using maps to come			A-Z, bus map													verbal instrctns	
Ruth:	maps			maps								contour lines						
Ruth:	learning to use a calculator			*														
Ruth:	spreadsheets	*		*														
Ruth:	visualising clock														visual-ising clock			
Ruth:	looking at TV paper							TV paper										
Sheda	getting up and going out:			clock										mental calc				
		4	1	6	1	3	0	1	0	0	0	1	1	2	2	0	4	0

		Created tools	Environmental							Persnl	Social	Abstract, cognitive						
			Concrete						Non-cncrte									
			Object/ space being worked on	Formal tools	Avoid frml tools	Informa l tools	Paper and pencil	Printed inform-ation				Sense of pattern	Count-ing	Calcul-ation	Visual-isation	Maths con-cepts	Memory	Intuit-ion
Sheda:	wanting to make bookcase			tape measure											visual-ising book-case			
Shelley:	tape measure: bunk beds			tape measure														
Shell & Sheda:	time for prayer	*				flowers openng			position of sun, size of shadows quality of light		body as sun-dial							
Shell & Sheda:	traditional measurement									*	*							
Shd, Slly, Rhi,	cooking without clocks		food		no clocks													*
Vera:	hours worked self-build			form			*							mental calc, non-stand alg				
Vera	assess health care plans						*	printed leaflets						*				
Vera	counting slides	*			no counting slides								*		size of wedge of slides		*	
Vera, Ruth, Jea	diff with 24 hr clock															24 hr clock		
		2	1	3	2	1	2	1	3	2	2	1	1	2	2	1	1	1
		15	**22**	**20**	**16**	**14**	**9**	**9**	**7**	**7**	**11**	**14**	**16**	**38**	**16**	**8**	**16**	**10**